GEOGRAPHICAL MAPPING OF ENGINEERING INSTITUTES IN BIHAR: STUDYING ITS AVAILABILITY

Dissertation

SUBMITTED TO THE NATIONAL INSTITUTE OF EDUCATIONAL PLANNING AND ADMINISTRATION, NEW DELHI IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE DEGREE OF MASTER OF PHILOSOPHY (M.PHIL), by

Rajiv Kumar

Under the Supervision of

Dr. Suman Negi

Department of Educational Planning

NATIONAL INSTITUTE OF EDUCATIONAL PLANNING AND ADMINISTRATION, NEW DELHI

2022

DECLARATION

Date:

I, Rajiv Kumar, hereby declare that this M.phil. Dissertation entitled *'Geographical Mapping of Engineering Institutes in Bihar: Studying Its Availability'* is based on my original research work, and to the best of my knowledge, has not been submitted in whole or in part in this University or in any other University for the award of any degree.

Scholar's Signature

Rajiv Kumar

CERTIFICATE

This is to certify that the dissertation entitled *'Geographical Mapping of Engineering Institutes in Bihar: Studying Its Availability'* is the work undertaken by Mr. Rajiv Kumar under the supervision of Dr. Suman Negi as part of his M.Phil degree. We recommend that this dissertation be placed before the examiner(s) for evaluation and award of the degree of M.Phil.

Signature of Department, Head — Supervisor's Signature

Department of Educational Planning, Prof. K. Biswal — Dr. Suman Negi

ACKNOWLEDGEMENT

This dissertation becomes a reality with the kind support and help of many individuals. I would like to extend my sincere thanks to all of them.

Foremost, I wish to offer this endeavor to our God **Almighty** for the wisdom he bestowed upon me, the strength, peace of my mind and good health in order to finish this research.

Then, I would like to express my gratitude towards **my parents and family**, who supported me with love and understanding. Without you, I could never have reached this current level of success.

I am highly indebted to **National Institute of Educational Planning and Administration, New Delhi,** for providing constant support and resources in completing this endeavor.

I would also like to thank **Department of Educational Planning**, National Institute of Educational Planning and Administration, New Delhi, and particularly to **Prof. K. Biswal, Prof. Geetha Rani and Dr. N. K. Mohanty.**

I wish to express my special gratitude and thanks to my supervisor **Dr. Suman Negi** for imparting her knowledge and expertise in this study and providing emotional support and guidance throughout the research process.

My thanks and appreciations also go to my **peers and** many other **people,** along with the **respondents** who have willingly helped me out with their abilities.

Thank you all for your unwavering support.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1- Introduction

1.1. Background

Quality Education is prerequisite for worthy employment and eradication of poverty. India aspires to become an economy of $5 trillion by 2025 and $ 10 trillion by 2032 from approximately $ 3 trillion in 2020 (Economic Survey 2020-21 & Hindustan Times 2020). This could be possible by utilizing the demographic dividend of the country. But, this also depends on how we capitalize our engineers in all three sectors namely primary, secondary and tertiary. And, thus there comes the role of higher education and particularly higher technical education. AISHE (2019-20) mentioned a total of 42343 colleges and 11779 stand alone institutions in India, where college density (number of college per lakh eligible population) varies from 7 in Bihar to 59 in Karnataka with all India average of 30. It also found that, at Undergraduate level the highest number, 32.7% of students are enrolled in Arts/Humanities/Social Sciences courses followed by Science (16%), Commerce (14.9%) and Engineering and Technology (12.6%). Then, when it comes to higher technical education, the country has total 3010 engineering and technology Institutes at UG and PG level, for the academic year 2021-22, with intake of around 1.4 million. From such numbers of institutes, 6.18 lakh students received engineering degree in the academic year 2019-20 (AICTE 2021). India is said to be among the largest producers of engineers in world, however only a few of its institutions are among the best internationally (TEQIP-III). But, the availability of such technical institutions and participation of youths under higher technical education remains uneven across the states of India. At the same time, this participation is limited by many barriers like financial, gender, caste, infrastructure and other such barriers. Non-availability of quality higher technical education within the state boundary is one such barrier, particularly for girl students and students belonging to scheduled class and other socio-economically disadvantaged groups (SEDGs). In fact, Accessibility, Availability, Affordability and Awareness could be termed as ‘Education Quartet’ for dissemination of knowledge. But, the location of engineering institutes in India seems not to be rationally distributed, thereby impacting the accessibility of quality technical education. So, this study examined the availability and participation with respect to higher technical education in different regions of the country.

1.2. Statement of the Problem

Technology and globalization have transformed countries into knowledge driven economies. And engineers have always played a key role in societal development and economic progress. AICTE committee for short and medium term perspective plan for technical education had anticipated shift in center of gravity of engineering programs from high income countries of North America and Western Europe to emerging economies of Asia and South America (AICTE 2018). Today high fraction of new engineering graduates come from four largest emerging economies namely Brazil, Russia, India and China, collectively known as BRIC countries, unlike previous decades when USA, UK, Germany and Japan produced majority of world engineers (Loyalka, Carnoy, Froumin, Dossani, Tilak, & Yang 2014).

Thus, engineering institutes in India have large capability to influence the skilled workforce of the country and outside world. And, with the large youth population in India, there is an opportunity of utilizing the demographic dividend of the country with the tool of 'Good Higher and Technical Education' (TEQIP-III). But, contrary to the general belief, the proportion of engineering enrollment to total population in India is very low (0.13%) compare to other nations (0.28 % for China, 1.17 % for South Korea and 0.45 % for European Union) (Loyalka, Carnoy, Froumin, Dossani, Tilak, & Yang 2014).

India has a total of 3010 engineering and technology Institutes at under and post-graduate level in the academic year 2021-22 with intake of 1.38 million. In the academic year 2019-20, around 6 lakh students received engineering degree (AICTE 2021). But, since these institutes are not rationally distributed across the states, it seems to impact the participation of youths in such education. Going further, availability is the first and foremost criteria to determine accessibility in education. But, as we consider less developed, largely rural and densely populated states like Bihar, which is the third most populous state of India and also the most densely populated state, they lagged in terms of availability of quality higher institutions. It was also reflected by poor college density which varies from 7 in Bihar to 59 in Karnataka as enumerated in AISHE (2019-20).

And, when it comes to higher technical education, merely 57 engineering and technology institutes exist in the state, which is very less for a state like Bihar having population of 11.6 million in 18-23 cohort in the year 2017(AICTE 2021& UGC 2018). Due to insufficient number of quality higher technical institutions in the state, thousands of students are forced to migrate to other states, causing additional financial burden. But, even this option has its own constraints, particularly for girls, scheduled classes, students from rural settings and other SEDGs.

At the same time, the low enrollment (participation) in higher education in the state was reflected through the Gross Enrolment Ratio for higher education in Bihar (14.5), which is almost half of all India average(27.1) (AISHE 2019-20). Also, Bihar shares international boundary with Nepal. So, quality engineering education in the state could make it, the potential destination even for the international students which could then contribute in the development of the state. Bihar has the legacy of hosting the ancient world famous Nalanda University, and hence the availability of quality technical education in the state could again make it, the hub for higher education. Engineers are crucial for development of any economy and hence the study of engineering institute is taken in this research paper.

Then, to understand the engineering education better in terms of geographical spread, mapping tool was used. Mapping is a tool required to assess future educational needs and identify avenues for equal and equitable access to educational facilities. School mapping exercise is quite popular in this regard, but no such map seems to exist for higher technical education. So, mapping the geographical location of engineering institutes across administrative division of Bihar, would help in examining its regional spread with respect to population and hence its impact on accessibility and availability of engineering education in the state. It would also help in estimating if there is a deficit in availability of engineering institutes in Bihar.

1.3. Conceptual Base

The present study attempted to understand the physical spread of technical institutions and correlate the same with the demographic size, so as to determine the ratio between availability of institutions and the demand based on the demographic size. The availability, location and spread of such institutions hold a key position and hence the use of techniques such as the Geographical Information System (GIS) will strengthen its understanding further more.

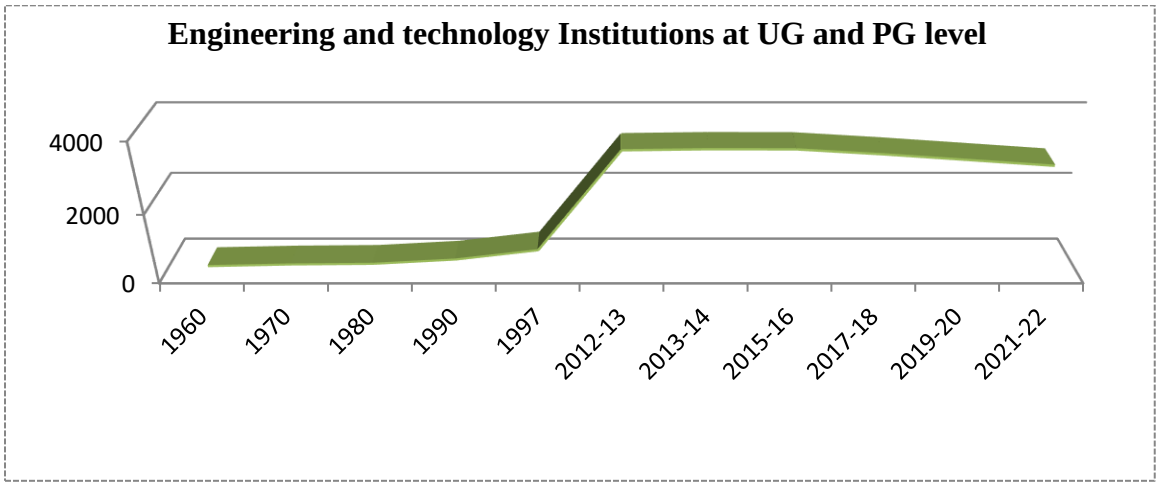
1.3.1. **Availability and Accessibility as 'Educational Twins'**

Universal access to education is paramount for sustainable development of a society and the availability of basic educational infrastructure is prerequisite for achieving this access. To facilitate universal access to school education in age group 6-14 years, the government had legislated Right to Education Act 2009 and schooling infrastructure is made available as per the set norms in various policies and programs, to achieve this purpose. But no such legislation seems to exist in India for universalizing access of higher education or technical education. So, accessibility could be denied due to variety of barriers like Gender barrier, Disability barrier, Marginalization barrier, Migration barrier, Administrative barrier, Infrastructure barrier, financial barrier or any other barriers. Sustainable Development Goal 4 talks about equal access to quality education and affordable technical, vocational and higher education. Increasing access would invite the need for additional support system in terms of infrastructure, resources and removal of other barriers.

Access typically refers to creating equal avenues and chances for everybody irrespective of religion, race, caste, sex, and place of birth or any disability. It is related with the means to approach or enter a place. For basic education, access means the ability to enter in education system based on intellectual merit and not restricted by financial or any other barrier. So, Accessibility here signifies the equal and equitable opportunities to education system. Much has been talked about access to school education and provisions made for distance norms applicable to schools (1 km for Primary level and 3 km for upper primary). But there seems lack of much insight on access to quality higher education and particularly technical education.

At the same time, this access could be achieved only if facilities are available. So, availability of education services becomes the first step to increase the access in education. Availability of education services could be achieved through investment in infrastructure and resource creation. Increasing college density, availability of better teachers, libraries and labs are ways to increase access to higher education. Availability of higher education within state is particularly important for increasing access of economically disadvantaged groups, who are facing many access barriers due to which they could not migrate to other places where such facilities are available. Hence, the availability of both the 'bricks and clicks world' under higher technical education is paramount for access in higher education. As we see the pattern in availability of higher technical education in India, it reflected a mixed pattern.

Figure 1.1: Trends in availability of engineering and technology institutions in India since 1960 to 2022



Source: Palit (1998) and AICTE

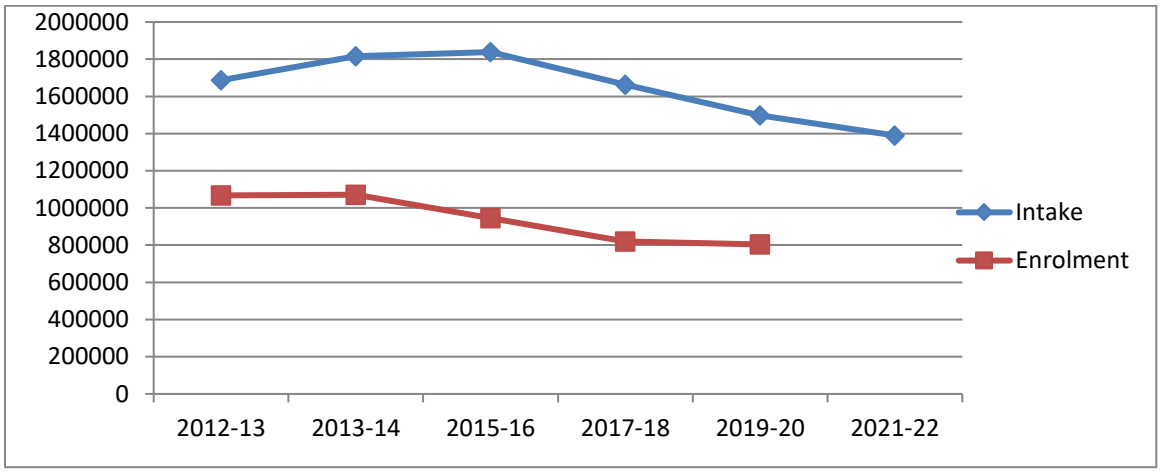
Since, 1960 to 1990s, there were slow growth in number of such institutes. After that, there was large growth in availability of higher technical institutions. But, in recent decades, it has nearly stagnated in terms of number. But, at the same time, quality of such institutions in terms of infrastructure, labs, employability etc. had also become a concern.

Although, there believed that there is overwhelming number of the higher education institutions (particularly engineering college) in India. However, this massive expansion

of engineering institutions in India is neither evenly distributed, nor seemed to provide access to the disadvantaged groups like women, scheduled castes and scheduled tribes. In fact, the increment in number of engineering colleges is not in same ratio for each region or state. So, still some states lack required number of engineering colleges in proportion to eligible population.

UGC (2008) emphasized for establishing at least 5000 more colleges across the country based on the GER of the constituent States. It measured the availability of educational institutions by college-population index (C-PI), i.e. number of colleges per lakh population in the age-group 18-23. The C-PI for colleges of general education in 2001-2002 was 8, while for Technical education, it was 0.9. The figure for Bihar was even less at 5.5 and 0.1 respectively. Now, as we notice the trend of capacity utilization, it again reflected the lack in availability of quality technical education in many higher institutions.

Figure 1.2: Trends in Capacity vs. Enrolment under engineering education in India on last decade



Source: AICTE dashboard assessed on 17th April 2022

Even, if the fast increment is noticed in enrolment for engineering education, but still the percentage enrolment in engineering education is not up-to its potential. The enrolment at undergraduate level in engineering and technology is merely 12.6 % and the highest numbers (32.7%) of students are enrolled in Arts/Humanities/Social Sciences courses (AISHE 2019-20). Then, according to PLFS (2018-19), the proportion of person of age

15 years and above under general education in India, who is graduate, is 8.5 percent and post graduate and above is 2.6 percent. The corresponding figure for Bihar is only 5.3 percent and 0.7 percent respectively. This proportion of such person having degree in engineering education at all India average is estimated at mere 0.6 percent .The low percentage of Bihar in comparison to all India average points towards low accessibility of higher education in general and engineering education in particular in Bihar.

Although, the seats in many engineering colleges in India remained vacant, but it is largely due to lack of quality education and poor employability as well as financial burden or disproportionate return of education, rather than quantity issue. At the same time, very less number of engineering colleges in a rural and densely populated state like Bihar, points towards poor availability and accessibility of such education. Due to lack of proper number of engineering college and then job opportunities ,brain drain from Bihar is going on, which is detrimental for the own state. In such scenario, students are forced to move out of the state, which is not always affordable for everyone. Particularly students belonging to disadvantaged groups and girls, face more problems in moving out of state for study purpose.

Hence, the Availability and Accessibility of technical education is a crucial issue for the development of human potential and upliftment of the society. Accessibility here signifies the reach of engineering education to the eligible population. The eligible population is generally considered of 18-23 age groups. Such access to eligible population would provide the ability to take part in engineering mainstream education settings. So, Accessibility of engineering education is first step to inculcate technological development and hence will aid in promotion of manufacturing sector.

Then, accessibility must also be seen not just in terms of availability of number of engineering colleges but also the intake capacity in proportion to eligible population, quality of engineering education and affordability. At the same time, accessibility gets affected indirectly by the employability of students passing from the regional institutes. Employability of engineering graduates is more of concern. Then, Management type of engineering institute also decides the accessibility in overcoming financial barriers.

Now, the question ahead is how to measure access objectively? There could be four indicators for determining accessibility of higher education. One is Participation Rate which is the fraction of young people engaged in higher education. Second is Attainment Rates which is percentage of the 25 – 34 year old population who has completed higher education. Third is the Educational Equity Index (EEI) which measures educational inequality by measuring the degree to which students from high socio-economic status backgrounds (as measured by parental education levels) are overrepresented in higher education. It is the ratio of percentage of all males of 45-65 years age with higher education degrees and percentage of all students whose fathers have higher education degrees. High EEI represent proportional representation. The fourth indicator is Gender Parity Index. The weightage assigned to each indicator is 25%, 25%, 40% and 10% respectively (Usher & Medow 2010).

1.3.2. **Geographic Information system**

The phrase "geographic information system" was coined by Roger Tomlinson in 1963. According to NRSC (ISRO), Geographic Information System (GIS) is a technological tool used to describe and characterize spatially referenced information for the purpose of visualizing, querying and analysis. Using spatial analysis, GIS users can combine information from many independent sources and derive entirely new layers of information by applying sophisticated set of mathematical, statistical, imagery and graphical tools.

A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. By relating seemingly unrelated data, GIS can help individuals and organizations better understand spatial patterns and relationships. The two major types of GIS file formats are raster and vector. Raster formats are grids of cells or pixels. Raster formats are useful for storing GIS data that vary, such as elevation or satellite imagery. Vector formats are polygons that use points (called nodes) and lines. Vector formats are useful for storing GIS data with firm borders, such as school districts or streets (National Geographic website).

GIS data could include spatial as well as non spatial data. The location information like latitude, longitude, address, population, educational data and other detailed information could be included depending on the need. The data could be collected in various forms like cartographic data, photographic data, digital data, or data in spreadsheets. GIS allows integrating these informations on a single map.

ArcGIS and QGIS are some of the GIS software used for this purpose. The geographical location of an institute is an important factor influencing accessibility. The location of institutes within a particular district or state aids in accessibility of education, particularly for students belonging to disadvantaged and disabled groups, financially weaker section and girls' students. Thus the use of GIS tool would facilitate the examination of availability of engineering institutes and determining the deficit of it. More procedural and technical information related to QGIS is included in chapter 4.

1.3.3. **Quality of Education**

The history of the world is divided into Before Common Era (BCE) and Common Era (CE). But due to the recent pandemic, this might be recognized as 'Before Covid Era' and 'Post Covid Era'. There is change in the whole landscape of talent demand and supply in this 'Post Covid Era'. And hence the concept of quality education is gaining renewed focus. Even 4th target of sustainable development goal (SDG-4) established by United Nation in 2015 is to ensure inclusive and equitable quality education and promote lifelong opportunities for all. Providing universal access to quality education is the key to India's continued ascent and leadership on global stage. It is the best way forward for developing and maximizing our country's rich talent and resources for the good of individual, society, country and world (Government of India 2020).

In fact, it is the quality of education which differentiates various societies and makes a country ahead of other in the competitive world. Quality education leads to innovation in society and enhance creativity among students. Quality education is one which promotes all three domain of learning, namely cognitive, affective and psychomotor domain. It not only makes a person more employable but also aids in his/her personality. It also helps

individual in achieving the full human potential to become a productive member of the society.

VVOB, a nonprofit organization, headquartered in Belgium says, "A good quality education is one that provides all learners with capabilities they require to become economically productive, develop sustainable livelihoods, contribute to peaceful and democratic societies and enhance individual well-being. The learning outcomes that are required vary according to context but at the end of the basic education cycle must include threshold levels of literacy and numeracy, basic scientific knowledge and life skills including awareness and prevention of disease. Capacity development to improve the quality of teachers and other education stakeholders is crucial throughout this process." It provides six dimensions of Quality education, which are Equity, Contextualization and Relevance, Child friendly teaching and learning, Sustainability, Balanced approach and Learning outcomes.

Then another such effort to improve quality was Technical Education Quality Improvement programme (TEQIP). It was a project of Government of India assisted by World Bank launched in 2002. TEQIP-III implemented for the period 2017-2020, is integrated with 12^{th} Five year plan objectives for improving the quality of engineering education with special consideration for low income states and special category states. The major challenge being faced by focus institutes in employability, equity and research is being addressed. Such efforts should be initiated by state governments as well to improve the quality of technical education.

Quality of education is a major concern in today's world. But, majority of engineering graduates in India receive low quality training in non-elite institutions while very few get high quality training in elite institutions. There is very less focus on demand and supply side mismatch in engineering education. Focus has to be laid on quality and standards of higher education (Tilak & Choudhury 2021). Quality education is something which makes education worth achieving. Employability is often used as indicator for quality education.

In fact, the term 'Quality Education' is a dynamic concept. It could be unique to a person which makes him/her more competitive with respect to others. The quality of skill education required for the same job profile keeps changing with time. And, hence the

definition of quality education is not sacrosanct. So, to measure the quality of education, Quality framework should be developed in collaboration with industries which could enhance employability. It should be made part of the curriculum of four year engineering courses. Then, to increase the credibility of this quality framework, a formal employability study could be done by government agencies in collaboration with industries.

Also, the elements of 'quality education' could be varied. Broadly it consists of Skills, abilities and attitude. It includes the realization and demonstration of one's own potential (One who aspires, attempt and accomplish), soft skills, creativity, problem solving aptitude, domain knowledge, demonstration of work values like team work etc. Aspiration here means the intent for learning and doing so that a necessary skill could be inculcated to the candidate. Attempt is related with dedication for work and belief in taking challenges. A firm looks for hardworking candidate.

Accomplishment is related with time management, which means ability to perform the task within given time frame. Self-awareness is also an important component of quality education. Knowledge about type of companies recruiting engineers, their work-culture, their requirements etc is also necessary for job applicants. Awareness among engineering students about startup ventures, new kind of emerging jobs like web development, graphic design, digital marketing, content writer, block chain development, cloud architect, mobile application development etc. also affect the employability.

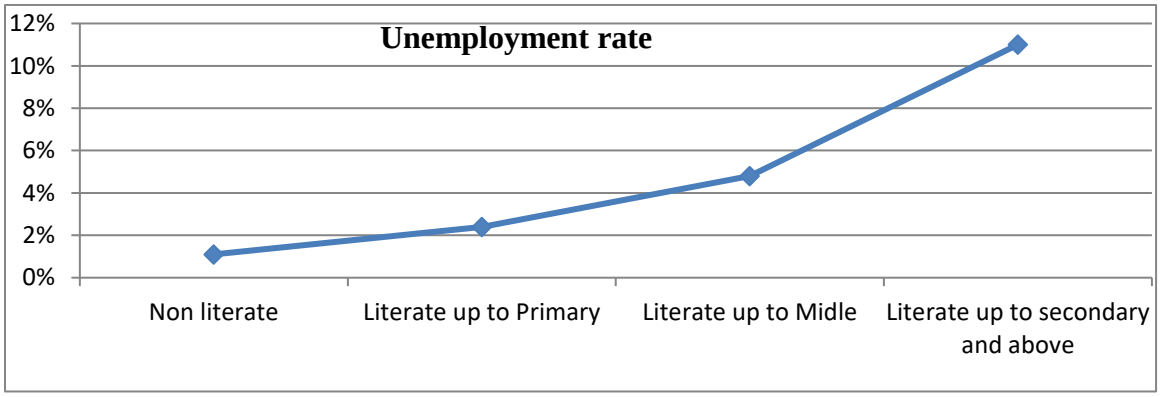
So, what is employability? Employability means the suitability, capability and readiness of a person for the job. It requires the skills and abilities for a particular job to be performed. Harvey (2001) defined employability as "the capability to move self-sufficiently within the labor market to realize potential through sustainable employment." So, employability refers to the personal traits for acquiring and maintaining job in return of remuneration. It is related with the set of qualifications for getting absorbed by job market and depends mainly on three components namely knowledge, skills and attitude.

Measuring quality in education is a complex and subjective process. There seems no standard way to determine quality of education. Employability of students is one such measure to determine the quality of education to some extent. But, again there is no fixed

way to determine employability. The various approaches could be a standard employability Test, measuring perception of industries and students through questionnaire and interviews, measuring skill gaps etc. In indirect way, it could also be analyzed in terms of how many got placed from college.

Unemployment rate could also reflect the quality of education being imparted in the society. For example, the unemployment rate during 2018-19 for persons in age group 15-29 years in usual status (ps+ss) at all-India average is 17.3 percent and the same for Bihar is 30.9 percent (PLFS, 2018-19, p.178). Usual activity status means the activity of a person during the reference period of 365 days preceding the date of survey, either principal (ps) or subsidiary activity (ss=activity for 30 days or more).

Figure 1.3: Unemployment for person age 15 years and above



Source: Based on data from PLFS (2018-19)

The above diagram represented an increasing trajectory of unemployment with level of education. The unemployment for person age 15 years and above for non-literate was least (1.1%) and for literate (secondary and above) was highest (11%). Although these figures of unemployment are not specific to engineers, never the less worrisome and it demonstrated the need for study of quality of engineers being produced.

1.4. Literatures Review and Research Gaps

1.4.1. ***Availability and Accessibility of Engineering Education***

AISHE (2019-20) reflects the poor accessibility engineering education in Bihar. Although, the survey presents the detailed picture for overall higher education, still inferences could well be drawn concerned with engineering education in Bihar and India. It revealed that college density (the number of colleges per lakh eligible population i.e. in the age group 18-23) varies from 7 in Bihar to 59 in Karnataka as compared to All India average of 30. Population in the age group 18-23 in 2019 in India was 142.3 million while the same for Bihar was 12 million. So, Bihar has one of the highest eligible populations. But, estimated Gross Enrolment Ratio (GER) in higher education in India is 27.1%, which is calculated for 18-23 years of age group. This proportion for Bihar is mere 14.5%. Also, the number of engineering and technology college in Bihar (3rd most populous state) is 55 while it is 455 in Tamil Nadu (Census 2011 and AICTE 2021).

Kumar (2021) noted that the creation of skilled labour pool requires an expansion of higher education in spatial proximity. Knowledge based economy has strengthened the link between education and economic prosperity. The location of higher education institutions (HEIs) in turn determines the localization of knowledge based economy and vice versa. HEIs are skewed towards the industrial regions.

Choudhury (2016) rightly pointed that during post liberalization period there has been a massive expansion of both institutions and enrolment in engineering education in India, particularly in private sector. During period 1985-2014, higher education institutions (HEIs) in India has increased from 5,427 to 40,373 which amounts to an annual average growth rate of 7.43 per cent, whereas engineering education institutions have increased by about 10 per cent per annum. During the same period, the share of engineering enrolment to total higher education enrolment in India has increased from 3.42 to 15.55 per cent. But this expansion is not equal for every state.

Tilak & Choudhury (2021) emphasized that access to engineering education is seen as an aspiration for social mobility and to reach a higher level of social status. The relative share of engineering and technology education under higher education fell sharply from nearly 16 percent in 2015-16 to below 11 percent in 2018-19. But given increasing

evidence of technology, one can expect that this trend would reverse. He also noted that expansion of private engineering education had widened the inequality in educational opportunities. It noted the AICTE data that against 1.3 million available undergraduate seat in 2019-20, only 0.9 million students took national entrance examination of JEE.

Ghose (2020) inferred that less than 1 percent of the population in Bihar is enrolled for higher education, both for general and technical streams. The Gross Enrolment Ratio in higher education among 18-23 years age group in Bihar is about 15 percent against national level of 25 % in 2016-17. To attain national level, the State needs additional 313 general colleges (Arts, Science and Commerce) and 236 Engineering Colleges. The student teacher ratio in Bihar is 39:1 which is substantially higher than the national average of 16:1 affecting quality of education. Poor quality of teaching and research facilities at higher education are responsible for brain-drain from the State. But how the quantitative figure about number of college is computed is not explained. And more importantly, the regional analysis is missed by the author.

Dahiya (2020) has drawn an interesting inference that adding even 500 colleges every year in a country where about 5 crores people are added annually is not good enough to improve equity and accessibility in higher education. Globalization, privatization and technologisation of higher education made it extremely expensive and disadvantage the lower class.

*1.4.2. **Mapping of educational institutes***

Mapping exercise helps users to choose the suitable institute and their requirements. Engineering institutes in India seems to be located unevenly across regions and spread not in rational pattern. It impacts accessibility to a large extent, particularly for disadvantaged groups. **Supuwiningsih, Santosa, NymUtamiJanuhari, & Putra (2018)** used Arcview GIS tool to provide more interactive and effective information and geographic information system of the spread of universities on the island of Bali. He used spatial and non spatial data about colleges. The GIS helps in managing data with complex and large-scale structures and assist in the decision-making process for both students as well as others.

Sabde, Diwan, Saraf, Mahadik, Diwan & Costa (2011) mapped 475 private pharmacies and their characteristics in Ujjain district, Central India. They used geo referenced digitized map for this purpose using Auto-Cad map software.

Khobragade & Kale (2016) mapped schools of Aurangabad district containing information like location and website of school if any, contact detail of school, school medium of schools, building of the image, school facilities and detail information in terms of Latitude, longitude and vicinity by using Geospatial technologies. It used Fusion table and Google API. The Google Maps Application Programming Interface allow for the insertion of Google Maps onto web pages of outside developers. Google Fusion Tables (or Fusion Tables) is a web service provided by Google for data management. Fusion tables can be used for gathering, conceptualize and sharing data tables.

Agrawal & Gupta (2016) had considered 204 schools in 114 villages under jasra block of Prayagraj district for school mapping exercise. Village map of Jasra block has been taken from National Information Center (NIC), Government of India. Trimble Juno 3B handheld GPS with 2-5 meter real time accuracy has been used to collect the location of each school. The school position data collected by the GPS is converted into the point shape file and the village boundary as the polygon shape file.

1.4.3. ***Quality Engineering Education***

Better quality education leads to better learning outcomes. But, rising youth unemployment is one of the most significant problem facing economies and societies in today's world. And, in 2020, the **World Economic Forum** has launched "The Reskilling Revolution" initiative for Better Skills, Better Jobs and Better Education for a Billion People by 2030 .India joined as a founding government member to this World Economic Forum's Reskilling Revolution. As per findings by the United Nations Children's Fund **(UNICEF),** more than 50% of Indian students and students from other South East Asian nations do not have the required skills for getting a job and are not on track to find 21st century jobs. Even, as per **AICTE (2021)**, only less than 50 percent engineering students are able to get campus placement.

NEP (2020) highlighted that entry into quality higher education can open a vast array of opportunities that can lift both individual and communities out of the cycle of

disadvantage. It mentions that quality education is one of the most pressing societal challenges which India needs to address today.

Loyalka, Carnoy, Froumin, Dossani, Tilak, & Yang (2014) found the government and administrators in BRIC nations are more focused on increasing enrollment in non-elites than raising quality. It is a matter of great concern. It also argued that students in non elite institutions have lower level of learning compared to students in elite institutions. This paper concluded that high proportion of engineering graduates in BRIC nations are not trained to same level as compared to their counterpart in USA, Europe or Japan.

Tilak & Choudhury (2021) concluded that the quality of engineering education is very unsatisfactory which would reduce the contribution of engineering education to economic growth. With massive expansion of poor quality engineering education, the employability of graduates is greatly questioned in labour market. They asserted that although India produces second largest engineering graduates in world, employability is questionable both in domestically and internationally. It pointed that while rate of unemployment is rising among the educated youth, the rate of growth is the highest in case of those with technical education. It has bought the argument that no new engineering colleges should be permitted to open for few years, but regional aspect must be taken care of in this regard. Although some states have disproportionate number of colleges, but at the same time other states like Bihar still lack requisite number of engineering colleges.

Diaz Lantada (2020) used the acronym "Engineering Education 5.0". The first three phases of engineering education (1.0, 2.0 and 3.0) were linked by him directly with the first three paradigm of Industrial revolution (First, second and third Industrial revolution). "Engineering Education 4.0" incorporated the use of Cloud computing, cyber-physical interfaces, internet of things, big data, additive manufacturing, among other, since 1990s even before the official coining of the term ''Industry 4.0'' in 2011. It was linked with project based learning, open lectures and massive open online courses. These were in sync with Bologna declaration (Italy) of 1999 which focused on learner centric approach. The author forecasted the new paradigm since year 2020 as "Engineering Education 5.0" which is characterized by holistic, flexible and dynamic approach, student centered and sustainability focused, focus on personal and professional development, research

oriented, collaborative, humanistic and ethical, combining knowledge based and outcome based approaches etc.

Pais-Montes, Freire-Seoane & López-Bermúdez (2019) emphasized that the acquisition of purely technological capabilities is no longer sufficient rather it should be complimented by incorporating meta-competence features such as attitude, teamwork, ethical and legislative skills, better communication and knowledge about how companies are organized. But this study was limited to only three branches. Also, out of the 51 competencies identified by this article, there is no clarity with regard to what constitute the domain knowledge as part of course and what is demanded by industries. In general, the article while analyzing the technical institutions went very much technical and complex. At the same time it seems country specific and university specific study.

SHL- National Employability Report-Engineers **(NER) 2019** claimed that employability of Indian engineers has not changed on an aggregate level since 2010, calling it as 'stubborn Unemployability'. It revealed that only around 3% of engineers possess new-age skills in areas such as AI, Machine Learning, Data engineering and Mobile technologies and on an aggregate level, employability in these areas is merely 1.5-1.7%. It highlighted that 80% of engineers are not employable for any job in the knowledge economy.

This number seems exaggerated but large number of engineers is graduating every year without supply side match of employment opportunities. The outdated curriculum, the non optimal quality of engineering education and non-transaction of course in sync with norms are real problem. Also 'knowledge economy' is a broad term. **ISR 2021** found that approx 40 percent of electronics, electrical engineering and computer science graduates are employable in India. It also revealed the youth employability to be 46 percent. So, the two reports seems to contradict each other in finding the employability figure which points towards subjectivity in determining employability. It demands the need for more credible study in this regard, may be by government agencies. Employable talent among engineering domain (B.E/B.Tech) hovered between 46-57% during period 2015-21. This was highest 57% in 2019 and lowest 47 % in 2021(Ibid).

Blom & Saeki (2011) highlighted that out of three skill factors, the core employability Skills contain a higher level of skills gap (0.98) compared to Professional Skills (0.92) and to Communication Skills (0.77).

Chithra (2013) demonstrated the strong need for awareness among the Indian graduates to know the employability skills required by the global talent market and emphasized the need of updating the curriculum at regular interval as per industrial needs.

Zaharim, Omar, Mohamed & Muhamad (2009) argued that new and fresh engineering graduates these days confront with more challenges and competitions in getting employed compared to previous graduates. The excellent academic degrees alone are inadequate and rather competencies and capabilities in generic skill are required in globally competitive world. The fact remains that many engineering institutes are not providing the skills which young people need to take advantage of emerging job in the 21st century which is churning for 'Industry 4.0'.

Mehrota & Santosh (2015) presented that over 10 percent of industrial growth testifies china as manufacturing hub of the world. The need of skilled workforce emerged from it has motivated Chinese planner for educational reform including vocational and technical reform.

Olfindo, Rosechin(2018) noted that skill based, knowledge makes worker more adaptable and capable of acquiring new skill as per changing demand.

Jaffrelot & Jumle (2019) pointed that 48 per cent of Indian employers reported difficulties filling job vacancies due to talent shortage. Freshly graduated engineers are on receiving end of this trend.

Upreti (2018) highlighted that technical education is in a mess as seats go abegging amid poor job prospects and an outdated syllabus that falls far short of current market needs. This crisis is even worse in states like Bihar where employability is one of the lowest for engineers. But on the other hand, the number of engineering colleges in Bihar is not in proportion to population.

1.4.4. ***Gender Issues***

The share of male student enrolled in Engineering and Technology is 70.8% where as female enrolment is 29.2% **(AISHE 2019-20)**. These less proportion of enrolment in engineering like professional courses seems to point towards the poor access of such education, particularly for girls and socio-economically disadvantaged groups (SEDGs).

NER (2019) noted that in India, there are 940 females for every 1000 males making the male-to-female ratio (MFR) 1.06. In contrast, the MFR in engineering colleges is 1.79. This shows that a lower proportion of females make it to engineering courses as compared to males. The analysis also showed that employability for males and females are almost equal, making each role bereft of any gender-bias. But this is contrasted by ISR 2021 which inferred that the employability of female in comparison to male was 3% higher in 2015 and 7% higher in 2021.

Dahiya(2020) also analyzed accessibility with respect to gender. While states like Kerala has 54% women in higher education, Bihar has lowest of 19%.

1.4.5. ***Regional Inequality***

NER (2019) observed a drop in employability of most roles while moving across Tier 1, tier 2 to tier 3 cities of campus location and also across metro vs. non metro cities. Then, analysis of employability across States placed Bihar, Jharkhand, Delhi, Haryana and West Bengal in the bin of top 25 Percentile states and Andhra Pradesh, Gujarat, Madhya Pradesh, Tamil Nadu and Maharashtra in the bottom 25 Percentile states.

But, this state bin is contrasted by **ISR (2021)** which claims that the states with maximum supply of employable talents both in 2015 and 2021 were Delhi, Orissa and Utter Pradesh. It does not include Bihar. The major concern is that the list of colleges excluded (top 100) and included in the data set is not mentioned in the NER 2019. Also, placing states like Bihar among highest employability bin could invite serious reservation by experts. This is also due to the reason that Bihar is one of the least favorable destinations for visit of companies in engineering colleges and the state also lack large number of manufacturing or service sector industries.

Altbach & Mathews (2021) in the article “Too many IITs, Unrealistic Expectations” said that “IIT system has expanded beyond its capacity to maintain its high standards and

is in danger of sinking into mediocrity." But, States like Bihar is in dire need of quality technical institutions, both government and private in order to increase accessibility of engineering education.

1.4.6. *Global comparison*

Much higher proportion of Indian engineers (37.7%) can't write compilable code, as compared to China (10.4%). The US engineers, on the other hand do four times better than Indian engineers in coding, and have only 4.0% candidates who can't write a compilable code **(NER2019).**

Blom & Saeki (2011) found that the Indian employers are less satisfied than their US peers on skills like Use of Math, Science, and Engineering knowledge, Applying Problem Solving skills, and Learn, Grow and Adapt.

Dahiya (2020) also noticed that accessibility of higher education to those eligible (in terms of those having passed senior secondary education) is merely 6 % for India in comparison to 60% in U.S.A., 54% in Canada and 33% in Israel.

Loyalka, Carnoy, Froumin, Dossani, Tilak, & Yang (2014) noted that a high fraction of new engineering graduates come from Brazil, Russia, India, and China. It found that only a minority of engineering students receive high quality training in elite institutions and majority receive low quality training. These countries devote less financial resource than developed nation in training engineering students. Where spending per student in higher education in Russia is upto $7000, it is least in India which is $1300. Also where graduation rate in USA is 56 %, it is 79% in India which means engineering program in India fail to weed out poorly performing students.

1.4.7. ***Course transaction and engineering curriculum***

NER (2019) rightly inferred that most engineering exam questions are based on rote learning and repeats from previous exams. Even students with no requisite expertise in the subject matter can qualify for these exams and score well. 68% of the candidates lack requisite domain knowledge, something which should be learnt in college. It also rightly suggests for employability assessment in the final year of university study which could be made a part of the AICTE criteria, NAAC and NIRF ratings.

There is also shift in nature of job which could be witnessed in the changing hiring pattern. The hiring intent of companies changed from 23 % in 2015 to 10%in 2021(ISR 2021). With the ongoing digital revolution and shift to work from home culture, new skills could be acquired through e-learning .AICTE must encourage more of such e-learning as per changing demand in industries and give recognition through certifications as part of four year engineering course.

Pais-Montes, Freire-Seoane & López-Bermúdez (2019) voted for mainly three kind of model. One way is to reinforce these generic skills is by allowing the main employers in the university's industrial area of influence to collaborate in some way in designing the HE curriculum. Second way is by guiding higher education process via project-oriented engineering education. Third way is a 'model Teaching Factory' in which the engineering classroom contains enterprise activity simulators and research and innovation activities that aim to reinforce technological competencies and soft skills.

Bordogna, Fromm & Ernst (1995) linked science with engineering education while discussing integrative engineering education. Like Science discover and create knowledge, engineering education must integrate knowledge to create new things with innovative ideas. He criticized the engineering curricula where separate courses are unconnected pieces whose relationship to each other and engineering process are not explained until late in baccalaureate education, if ever. It fails to make connection and integration which is core of education.

Menon, Keerthi (2014) stated that unemployment level of the educated workforce – defined as secondary and above level of education, is almost six times that of the workforce educated only up to the primary level. She rightly inferred that employability is bigger challenge than unemployment in present world. She concluded that engineering students are often equipped with technical knowledge, but lack of soft skills leave them not prepared for the contemporary requirements of workplace. She emphasized on curriculum mapping as important step for improving employability.

Nayar (1970) found that practical training is very unsatisfactorily organized today with industry taking very little interest. Also technical education is very expensive. It raised an important concern that for operating any meaningful admission policy, it is necessary to know not only how many engineers will be required by the economy in next10 years but

also their breakdown by educational levels specialties. Also a strict watch should be kept over employment situation. Industries need to be closely involved in the periodic reviews of manpower forecasts.

Chatterjee (2021) points that lack of career opportunity in colleges lead to loss of academic interest among students. It says that, "The entry wall is high, the exit wall is low, and the four-year syllabus is an obstacle course between the student and an employer…" So, syllabus should be continuously in sync with the industrial needs.

UNESCO strategy for TVET system (2016-2021) aimed to strengthen the technical education system in member states. And, **UNICEF-GBC "Education 2030 skill scorecard"** report says that only 19 percent of Indian student on track to reach learning benchmark. These again emphasize the need for quality engineering education for passing graduates.

*1.4.8. **Special Case of Bihar having International Boundary***

There is a geographical divide in availability of engineering campuses. There is a large potential of Bihar in this sector which still remained unutilized. Bihar share international boundary with Nepal which presented an unique opportunity for both India and Nepal to harness in education sector.

As per AISHE 2019-20, "Highest share of foreign students come from the neighboring countries of which Nepal is 28.1% of the total, followed by, Afghanistan 9.1%, Bangladesh 4.6%, Bhutan constitutes 3.8% and Sudan 3.6%." Among foreign students in India, B.Tech programme has highest (9503) enrolment, more than double the enrolment in program (B.Sc.), which is having second highest enrolment. But, despite Nepal being the neighboring state, top 10 state destination of foreign students in India does not include Bihar. Bihar has only 0.3% of foreign students in India.

1.4.9. ***Gap Identified***

There is lack of much insight on availability and accessibility of engineering education in India at regional scale. Availability of quality higher technical education is the foremost step to enhance accessibility of such education. But, no such map seems to exist, where all the engineering institutes of Bihar or the country could be located. The underdeveloped and largely rural states like Bihar have different peculiarities than other states in terms of population, availability of infrastructure and other factors. For example, Bihar is the third most populous state of India but having disproportionately less number of engineering colleges in the state. Then, there is also lack of proper research on quality of graduating engineers and the quality of engineering education provided in the institutions. At the same time, employability of engineers, graduating from different parts of the country is also a prime concern, which needed further study. While analyzing employability of engineers, there is also a need of considering the supply side constraints, particularly for states like Bihar. Only few recruiters tend to visit the state. Also, employability is a dynamic concept but very less formal study on employability by any government bodies or its constituents seemed to exist.

1.5. Research Questions and Objectives

Research Questions

1. How are Management type, College Density, Location and Placement rate impacting the participation of students under higher technical education?
2. Does the availability of HTI meet its future demand, especially in a highly populated, high density, rural and backward setting of the study area?
3. What are the factors which determine the location and distribution of higher technical institutions (HTI) in a state?

Research Objectives

- To analyze the participation of youth under higher technical education.
- To examine the availability and distribution of HTI with reference to state of Bihar.
- To examine the availability of various disciplines and programme levels under higher technical education.
- To find the factors that determines the location and distribution of HTI.

1.6. Research Methodology

1.6.1. ***Method***: Quantitative method.

1.6.2. ***Research design***: Exploratory research

1.6.3. ***Tools:*** GIS, Field Visit, RTI, and Semi structured questionnaire. Right to Information Act 2005 was utilized to ask some of the information like intake, admission rate, course details and other such information to the university and some individual institute.

1.6.4. ***Population****:* The reference population for this research paper was the 18-23 age group people and faculties and administrative heads of engineering institutes located in Bihar. It also included students enrolled in PhD degree.

1.6.5. ***Sample:*** So, the sample group was engineering institutes of Bihar and administrative heads and faculties of the technical institutes located in Bihar along with 18-23 cohorts of each state and at district level for Bihar. The doctorate students belonged to IIT-Patna and NIT-patna.

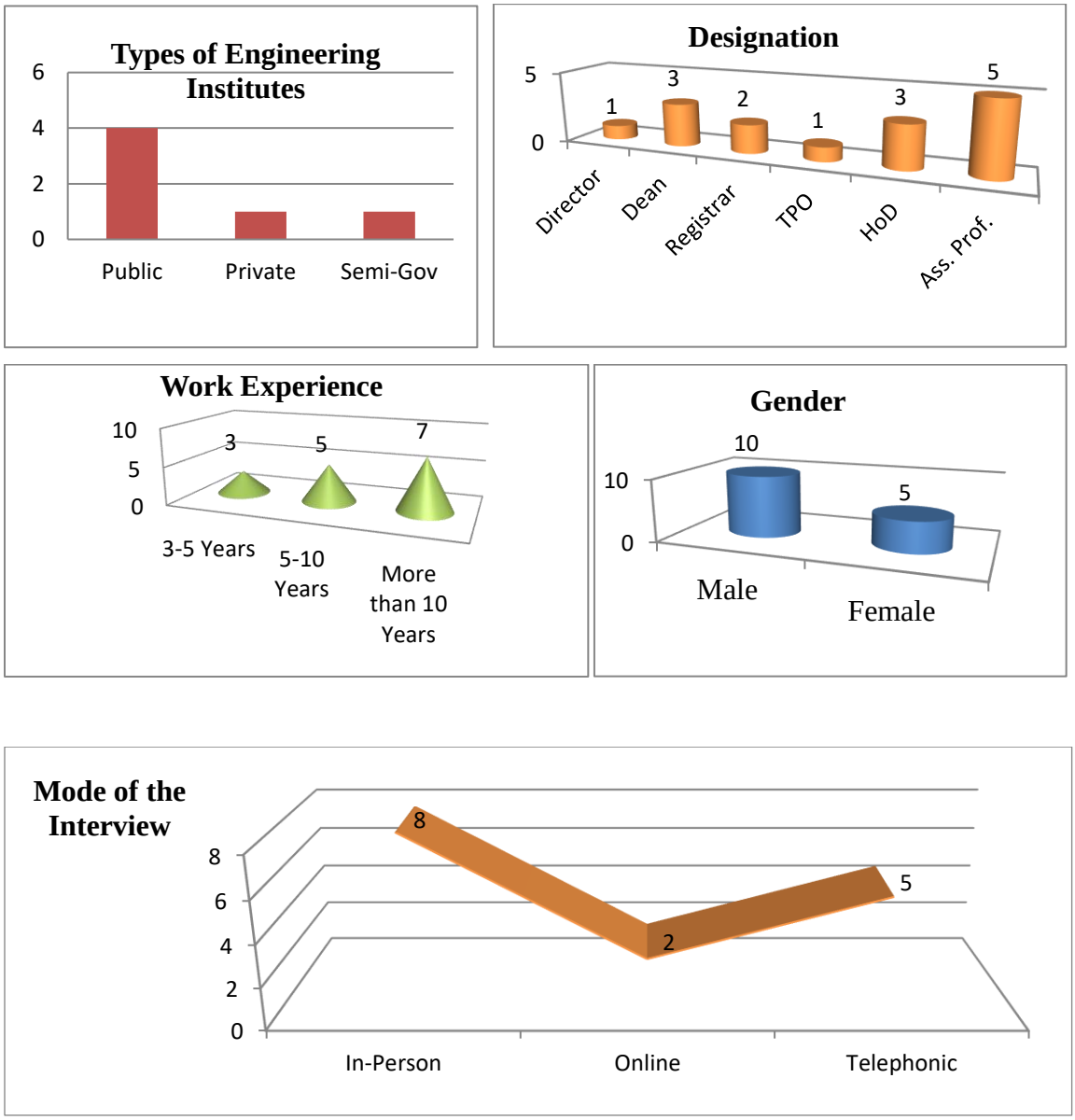
1.6.6. ***Sampling Technique****:* The Purposive sampling technique was used here, due to time and resource constraint.

1.6.7. ***Data Type:*** Both primary and secondary data were used in this research. Primary data was collected through semi-structured questionnaire and interviews. Mails were sent to more than thousand faculties and administrative heads belonging to engineering institutes in Bihar, requesting them to fill the Google form containing semi-structured questionnaire. Among them, 90 persons have given their feedback. Also, 15 people were interviewed in various modes as shown below. Field visit is

also done to few engineering institutes located at Patna to collect primary data. Secondary data from various sources like AICTE, AISHE, UGC, Census, and website of individual engineering institutes in the region was collected. A detailed literature review was also conducted.

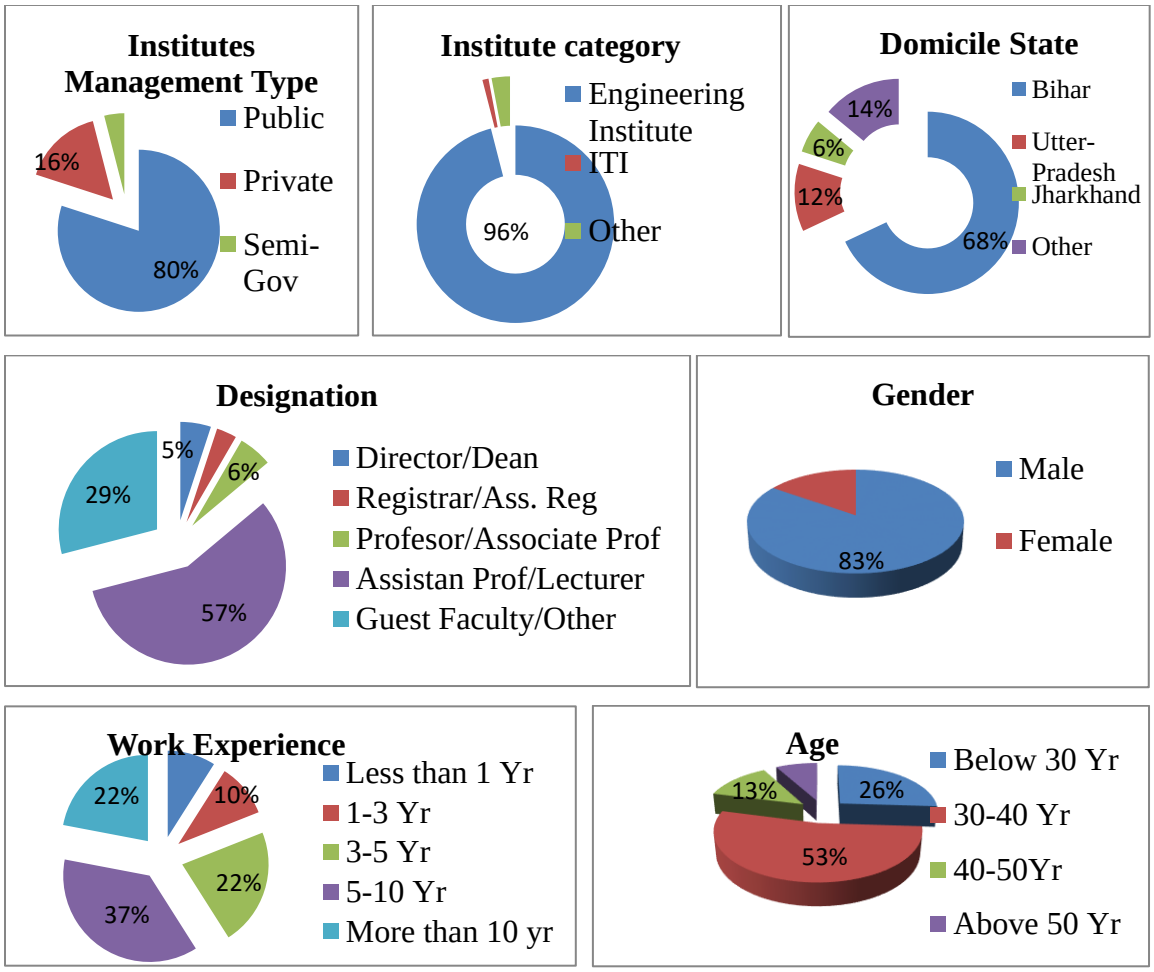
1.6.8. ***Participants:*** In total, 15 persons were interviewed and 90 respondents had filled google forms sent through mails.

Figure1.4: Various details of the participants in the Interview



Below are the details of the participants who filled Google-form containing semi-structured questionnaire. Repeated mail was sent to people associated with engineering institutes located in Bihar like faculties, administrative people and doctorates from IIT-Patna and few other institutes. Total 90 of them have responded.

Figure 1.5: Description of the Respondents who participated in written semi-structured questionnaire



1.6.9. ***Data Analysis:*** For data analysis SPSS, MS-Excel and QGIS software were used. Then participation of youth in higher technical education is analyzed by computing engineering institute density with respect eligible population (18-23 year age-group) and performing regression analysis with the help of SPSS software, considering other variables. The factors determining location was ascertained through the questionnaire on 5 point Likert scale to research scholars, administrative heads and

faculties of the technical institutes located in the state. The pattern of availability of various discipline and program level was found through secondary data. Then, the QGIS, an open source software, has been used as a tool for analyzing geographical information system and mapping of engineering institute.

1.6.10. ***Challenges:*** While conducting this research, the COVID19 restrictions, resource and time constraint were some of the major challenges.

1.6.11. ***Limitations:*** There were also few limitations during this research. The sample size of this paper is certainly not an ideal figure. The author targeted the sample size in the range 150-200. But, due to the limited time during the M.Phil research, added by COVID-19 restrictions and busy schedule of Assistant professors and head of the department and administrative heads, it has put much restrained in increasing the sample size. So, even after putting much effort, the author could collect a sample size of only 90. Never the less, it became helpful in understanding the problem at hand.

1.7. Chapterization

Chapter 1: Introduction

This chapter included background, concepts, literature review, methodology, Research questions, objectives etc.

Chapter 2: Availability and Participation with respect to Higher Technical Education

This chapter examined the participation rate under engineering education in India. It also aimed to understand the impact of various elements on participation and hence conducted regression analysis of participation with respect to management type, intake, college density and placement rate. Apart from this, it also analyzed the availability of existing institutes in Bihar and the pattern in availability of various engineering disciplines. Then it also examined some of the quality issue under engineering education and suggesting what needs to be done to improve the quality of technical education.

Chapter 3: Factors Influencing Location of Institutes

There is uneven distribution of technical institutes in India. In general, southern states seem to have large number of engineering and technology institutes, while states like Bihar has very few of such institutions. So, this chapter has analyzed the factors, which affects the establishment of technical institutes in a region and its distribution.

Chapter 4: Projection and Mapping

This chapter has projected the future demand of seats under engineering education and suggested the number of new engineering colleges required in the region. It also consisted the actual mapping of engineering institutes of Bihar across regions and the details of mapping tool used.

1.8. Implication of the Study

This research work has presented insight on status of engineering education in the country in general and Bihar in particular, which is the third most populous state of India. The development of eastern region is paramount for development of whole country and for this engineering education is a crucial link. So, the study of participation of youth in technical education has helped in analyzing the use of demographic dividend of the nation. Then, the geographic perspective of engineering education could be understood only with spatial data for which GIS is a useful tool. So, this work has helped in understanding the regional spread of higher technical education in Bihar. Further, this mapping could be extended for whole India in future. It would show great discernment in decision making for all stakeholders like students, parents, policy makers and AICTE.

****

****

Chapter 2: Availability and Participation with respect to Higher Technical Education

This chapter has examined the participation rate under engineering education in India. Participation under engineering education is limited by many constraints (variables). So, there performed the regression analysis of participation with respect to management type, intake, college density and placement rate. This aimed on finding ways to increase participation. Apart from this, it analyzed the availability of existing institutes in a rural setting of the study area like the state of Bihar and country along with the pattern in the availability of engineering disciplines and programme levels. Then, it also examined some of the quality issue under engineering education and suggested what needed to be done to improve the quality of technical education.

2.1. Availability of technical institutes

In this research paper, the availability of technical institutes has been examined through two themes. One is availability of institute with quality technical education in the region and other is number of such institute required by 2035-36 in less developed states like Bihar. New Education policy 2020 aimed to increase Gross Enrolment Ratio in higher education from 26.3% (2018) to 50% by 2035. More HEIs targeted to be established and developed in underserved regions to ensure full access, equity, and inclusion. It aimed that by 2030, at least one large multidisciplinary HEI to be established in or near every district. It said that, while a number of new institutions may be developed to attain these goals, a large part of the capacity creation will be achieved by consolidating, substantially expanding, and also improving existing HEIs. So, 3.5 Crore seats are proposed to be added in higher education (Government of India, 2020). In this context, projection of required number of higher technical institutes in the state of Bihar was done in Chapter 4. Here, present situation is being analyzed.

First of all, Access to education is important in building choices and enlarging human capability. So Accessibility of engineering education is an important component of human development and hence social and economic development and growth of the nation. Accessibility is also dependent on public spending on engineering education. But,

accessibility could be talked about only if there is availability of higher technical institutions in the region. In general, where southern states have more engineering colleges in proportion to eligible population, Bihar seemed to have under-accessibility with less number of engineering colleges. For analysis, this paper has considered the eligible population as the people in the age group of 18-23 years. Table below presented the availability of engineering education by determining the number of engineering college at undergraduate and post graduate level per lack eligible population.

Table 2.1: Engineering college density and percentage enrollment in various states of India

State/UT	[1]No_Eng-Inst	[2]Proj_Poplatn	[3]Colg_density	Intake	Girls_enrl (%)	Total_Enrl	[4] Enrl (%)
Andhra Prad	311	5495217	5.66	179519	40.2	102798	57.3
Arunachal	2	159922	1.25	558	31.8	484	86.7
Assam	19	3729138	0.51	5399	25.2	3034	56.2
Bihar	57	11607454	0.49	14705	14.9	8786	59.7
Chandigadh	6	187731	3.20	2488	20.4	1921	77.2
Chhattisgadh	43	3127770	1.37	17899	22.8	8085	45.2
Delhi	20	2298017	0.87	11507	16.3	7048	61.2
Goa	5	177298	2.82	1614	27.1	1160	71.9
Gujrat	129	7217084	1.79	63722	16.4	30216	47.4
Haryana	124	3184553	3.89	40659	18.1	16601	40.8
Him.Pradesh	17	726614	2.34	4230	19.4	1569	37.1
*J & K	12	1298156	0.92	3783	25.3	2288	60.5
Jharkhand	22	3830303	0.57	7361	15.7	4110	55.8
Karnataka	203	6982633	2.91	119360	35.7	76298	63.9
Kerala	168	2992566	5.61	60714	38.8	31891	52.5
Madhya Prad.	188	8905538	2.11	81503	20.5	48224	59.2
Maharashtra	370	13269732	2.79	152675	29.6	81134	53.1
Manipur	2	329418	0.61	186	17.5	126	67.7
Meghalaya	1	339836	0.29	420	20.0	245	58.3
Mizoram	1	128848	0.78	150	23.3	90	60.0
Nagaland	2	244329	0.82	420	32.1	78	18.6
Odisha	94	4623929	2.03	41057	24.0	22373	54.5
Punjab	103	3162828	3.26	36001	21.1	16308	45.3

[1] Number of Engineering Institute at UG and PG level excluding diplomas in the year 2019-20
[2] Projected population in the age group 18-23 year as per UGC 2017-18,higher education state profile
[3] Calculated by dividing No_Eng-Inst by Proj_Poplatn and then multiplied the quotient by 100000
[4] Calculated by dividing Total_Enrl by Intake and multiplied by 100

Rajasthan	116	8930612	1.30	44419	22.3	17652	39.7
Sikkim	2	77623	2.58	734	18.5	459	62.5
Tamil Nadu	524	7074857	7.41	316338	31.0	160936	50.9
Telangana	222	3979862	5.58	130776	38.5	77132	59.0
Tripura	3	432816	0.69	678	33.2	385	56.8
Uttrakhand	31	1203988	2.57	11206	18.4	5308	47.4
Uttar Pradesh	258	24898805	1.04	101299	20.4	47787	47.2
West Bengal	96	10872798	0.88	38281	21.4	22776	59.5
All India	3168	141829528	2.23	1497999	29.9	800680	53.4

Source: Author's calculation based on data from AICTE website for year 2019-20 for each year noted individually for each state/UT and projected population taken from source UGC (2017-18)

Although seats in many engineering college in India remain vacant, but this could not and should not be extrapolated to conclude that there is sufficient availability of HTI in the country. At the same time, the number of engineering college in proportion to eligible population is not distributed in rational manner. This arbitrary distribution of engineering institutions might have led to under-accessibility in some states and over-accessibility in other states. For example, the number of engineering college at undergraduate and post graduate level per lack eligible population is more than 5 in states like Andhra Pradesh, Kerala, Tamilnadu and Telangana. But this figure is less than 0.6 in states like Bihar, Jharkhand, Assam and Meghalaya.

Tamilnadu seems to have more availability, with the college density (Number of college per lakh eligible population) of 7.41, while Meghalaya have least availability with college density as merely 0.29. So the number of new engineering colleges should be decided considering college density as one of the factor. The college density at All India average is 2.23. When accessibility of engineering college is analyzed with respect to college density, then only 12 states have more access than India average. These states are Uttrakhand, Telangana, Tamilnadu, Sikkim, Punjab, Maharashtra, Kerala, Karnataka, Himachal, Haryana, Goa and Andhra Pradesh. So, the lower college density for engineering education points the need for opening more engineering colleges in the region.

The availability of engineering education could even be better seen with respect to intake capacity in proportion to eligible population. At all India level, the intake of engineering

students per lakh eligible population is 1056. This figure for Tamilnadu is more than four times of All India average which again points towards over-availability in the region. It is more than 3000 for both Andhra Pradesh and Telangana and 2029 for Kerala. So, Southern states again witness more access of engineering education in comparison to other states, when access was seen in terms of availability. The Intake per lakh eligible population for Bihar is mere 127 which pointed towards low access of engineering education in the state. The eight north-east states in India, except Sikkim also lie on lower side of intake proportions with respect to eligible population. Here, it needed to be clarified that access has many parameters and availability is one such important parameters which aids in increasing accessibility.

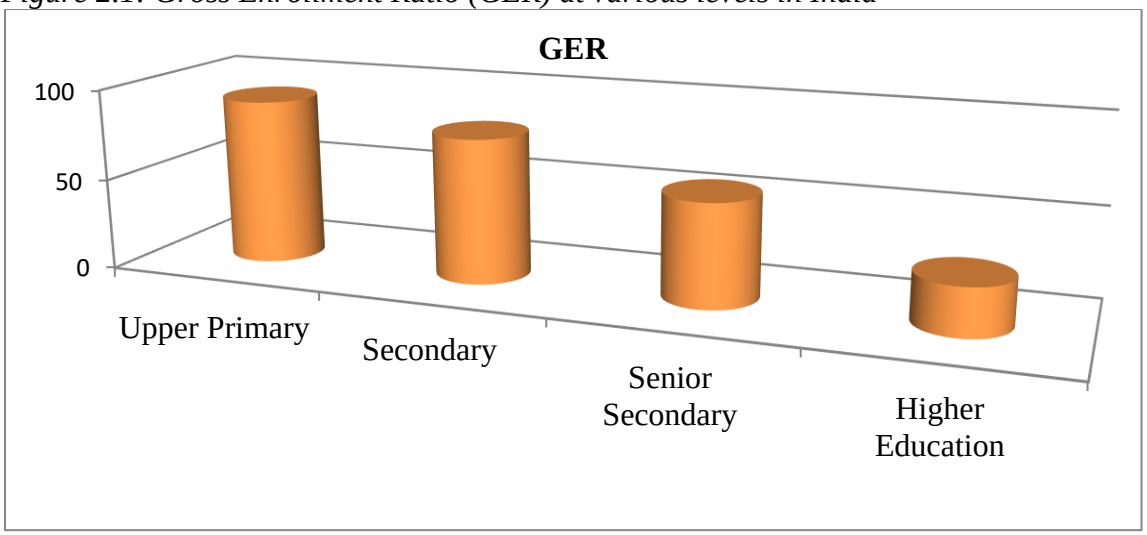
Now, when we analyze the enrollment percentage with respect to intake, it also presents peculiar pattern for availability of engineering education. The enrolment varies from as low as 18.6 percent in Nagaland to as high as 86.7 percent in Arunachal Pradesh. At all India level it is 53 percent, which shows that around half the seats in engineering colleges goes vacant. It is 51 percent in Tamilnadu which was having the highest engineering college density otherwise. The enrollment percent with respect to intake is around 60 percent for Bihar which is higher than national average. States like Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Maharashtra, Nagaland, Punjab, Rajasthan, Tamilnadu, Uttrakhand and Utter Pradesh have lower enrollment percentage with respect to intake than national average.

But the lower enrolment percent with respect to intake and vacant seats at engineering colleges should not be seen as over accessibility or availability of engineering education in India. It is impacted by many factors like quality of engineering education and financial and other barriers in taking admission. Also the low enrolment in engineering education is in sync with the enrolment in senior secondary and higher education as shown in figure 2.1 below.

Often, many engineering seats remain vacant in institutions. The lagging quality of engineering education and non-proportional return of education are main reason for this situation. Then placements, lack of infrastructure in terms of laboratories, classrooms,

equipments, lack of qualified faculties are few another reasons which cause the seats of engineering colleges going vacant.

Figure 2.1: Gross Enrollment Ratio (GER) at various levels in India



Source: Government of India (2020)

The reason for vacant seat at post graduate or doctorate level is also the fact that many students get enrolled in B.Tech just for sake of getting any graduation degree. There seemed a saturation of engineering degree. At the same time, enrollment at higher education also depends on job prospects. The reservation of seats for different categories is another reason for vacant seats. The reserved seats if not filled, could not be assigned to other category students which cause the seat going unoccupied.

But, whatever the reason of seats going vacant, the non optimal utilization of capacity leads to administrative burden on institutions, which in turn impacted the quality of higher technical education in terms of human resource and infrastructure creation. So, there is need for overcoming this vicious cycle. As the quality of engineering education would improve, the return of technical education for students would be enhanced and hence it would further attract student, thereby increasing participation and reducing vacancy of seats at HTIs. The issue of participation under technical education was analyzed ahead under section 2.2 in this chapter.

Going further, the issue raised, if we should focus on expanding the intake capacity of existing institutes rather creating new institutes?

> One 'XYZ' engineering institute in south India is having up to 1000 students in Computer Science branch. The fee structure for same branch in same college is different, depend on whether someone in merit list. But admission in any way is confirmed if a student is ready to pay the higher fee. Such institute compromise with quality of education as with large intake, such proportionate increase in lab/infrastructure is also required which is not followed.
>
> Administrative Officer, Male, Public Institute, Patna

So, sometimes, the institutions misuse the raised intake capacity by admitting more students in booming branches. The placement is shown high by colluding with few branded companies. Such companies hire the graduates for temporary period, assign them, non-core benches in companies and then simply lay off after a year or in months. By doing so, colleges are able to show higher placement which is not true on ground.

So, the problem in increasing intake capacity is the misuse of it and compromising the quality of engineering education. It was found that with increase in intake capacity, quality often deteriorates. Since, with increase in intake, the facilities in form of labs, equipments, and experts also needed to be enhanced which would require additional fund between 2-3 crores, which was often not spent. This is further understood with the help of small case study of NIT-Patna.

> **Case Study: NIT-Patna: Effect of increasing intake capacity**
>
> For, ECE branch at NIT Patna, there are 160 students. They were divided into two sections of 80 each. Then these students were further divided into group of 40 each. Then for practical purpose, a group of 3 students each are created. Thus around 15 different lab setups are required. Now, for effective practical of engineering education, it would have been better if small group of 2 students each would have been constituted. But it would require additional number of lab setups and space. This situation gets worse if intake is increased.

Case study continued…..

At the same time, the requirement of infrastructure for other branches like Civil Engineering, Mechanical and Electrical engineering, is even more in comparison to ECE or CS branch. Since these branches require huge setup and bigger equipments which are also more costly in general. Hence expanding intake would increase crowd and impact quality of education.

"Students faculty ratio at engineering colleges should be 10:1.But even at IIT-Patna and NIT Patna, this ratio is around 18:1. The ratio is even poorer at other colleges."

Faculty, Female, Public institution, Patna

Now, analyzing the primary data, there reflected mixed view regarding availability of HTI and opening of new institutions when perception of respondents was analyzed. Many a times, establishment of educational infrastructure is used as a tool of economic development in the region. It further boost the creation of other infrastructure in the region like roads, shopping malls, residential areas and many related economic activities.

More colleges should be opened, since colleges also develop the economy of the surrounding areas. For example: Bihta in Patna has developed after coming of IIT-patna and other colleges in this region.

Administrative Officer, Male, Public Institute, Patna

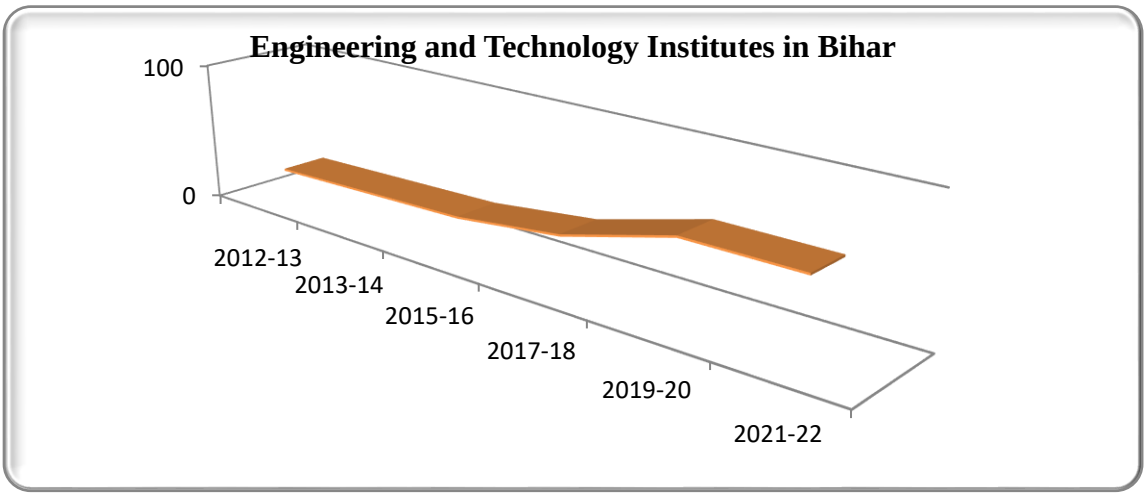
But there is also concern that increased number of IITs and NITs had affected quality of engineering education. There is lack of sufficient funding for research, labs and equipments in these colleges after increase in number of such colleges. The employability has been affected and now even IITs are not getting hundred percent placements of engineering graduates. The more such quality issues were discussed in section 2.3 of this chapter.

2.1.1. Availability in Bihar

Bihar has different peculiarities in terms of development, population and resources, which also gets reflected in number of institutions and hence quality of education in the state. As per AICTE (2021), Bihar has 57 engineering and technology institutes in 2021-22. So, the issue at hand is weather the state needs more engineering institutes. Respondents gave mixed response. Availability is the first and foremost criteria to determine accessibility in education. Bihar is third most populous state of India and also most densely populated state. But when it comes to higher technical education, merely 57 engineering and technology institutes seems very less for a state like Bihar having population of 11.6 million in 18-23 cohort in the year 2017(UGC 2018).

The figure 2.2 represented the growth of engineering and technology institutions in Bihar. The number of such institutions in Bihar has increased by almost 1.5 times in last decade. But, this number must be seen in terms of proportion of eligible population in Bihar, which was examined further in this chapter.

Figure 2.2: Trends in availability of engineering and technology institutions in Bihar in the last decade



Source: AICTE (2021)

The table below showed that the total intake of all engineering institutes in Bihar in the academic year 2018-19 was 11224 with enrolment of 1040 girls and 4848 boys. A total of 4208 students have graduated in the same year as engineers and 1102 among them have

been placed (AICTE 2021). From the projected population data given by National Commission on Population (2020), it was found that the eligible population in Bihar is 9.5 percent of eligible population of India in the year 2021. But, the number of engineering colleges in Bihar is only 1.9 percent of corresponding number in whole country for the same year. In terms of total enrollment under engineering education, this figure comes out to be 1.1 percent for the year 2019-20 (calculated based on data from AICTE 2021).

Table 2.2: Bihar Institute wise data of intake, enrollment, placement and management type

Institute Name	2018-19			2020-21			Management Type
	Intake	[1]Enrl	Plcmt	Intk	[1]Enrl	[2]Plcmt	
Loknayak jai prakash institute of technology	240	257	16	240	251		Government
Siwan engineering and technical institute	300	55	0	225	37	3	Private_Self Financed
Government engineering college	0	0	0	240	83		Government
Government engineering college	0	0	0	240	66		Government
Government engineering college	0	0	0	240	131		Government
Motihari college of engineering	240	244	22	240	257		Government
Government engineering college	0	0	0	240	72		Government
Sitamarhi institute of technology	240	243	0	240	228	2	Government
Muzaffarpur institute of technology	275	310	4	275	271	64	Government
Patna sahib college of enginering & technology(pscet)	300	70	52	390	135	51	Private_Self Financed
Exalt college of engineering & technology	240	29	29	300	89	12	Private_Self Financed
Government engineering college	240	195	0	240	201		Government
Government engineering college	0	0	0	240	240	0	Government
Dr APJ Abdul Kalam Women's Institute of Technology	120	65	42	120	53	35	Government
Darbhanga college of engineering	240	248	9	240	274		Government
Government engineering college	0	0	0	240	187		Government
Saharsa college of engineering	240	245	0	240	254		Government
B. P. Mandal college of engineering	240	233	0	240	219		Government
Supaul college of engineering	240	230	0	270	198		Government
Katihar engineering college	180	171	0	240	202		Government
Millia institute of technology	420	99	2	420	180		Private_Self Financed
Vidya vihar institute of technology	240	67	42	210	71	9	Private_Self Financed
Purnea college of engineering	240	227	0	270	242		Government
Azmet institute of technology	180	98	21	300	58	39	Private_Self Financed
Millia kishanganj college of engineering & technology	180	50	0	180	92	0	Private_Self Financed
Government engineering college	0	0	0	240	67		Government
Shri phanishwar nath renu engineering college	0	0	0	240	24		Government
Moti babu institute of technology,forbisganj	300	14	37	270	110		Private_Self Financed
Adwaita mission institute of technology	300	16	0	246	8	0	Private_Self Financed

Government engineering college	240	208	0	240	172		Government
Bhagalpur college of engineering	300	327	22	300	291	35	Government
Government engineering college	0	0	0	240	116		Government
Government engineering college	0	0	0	240	103	0	Government
Government engineering college	240	189	0	240	146		Government
Government engineering college	0	0	0	240	119		Government
Government engineering college	0	0	0	216	158		Government
Rashtrakavi ramdhari singh dinkar college of engineering	240	255	0	240	246	56	Government
Sityog instituteof technology	540	45	59	390	160		Private_Self Financed
Government engineering college	0	0	0	240	173		Government
Gaya college of engineering	240	269	6	240	236	20	Government
Buddha institute of technology	300	29	43	300	116	24	Private_Self Financed
Government engineering college	0	0	0	240	183		Government
Government engineering college	0	0	0	240	90	0	Government
Government engineering college	0	0	0	240	188		Government
Government engineering college	0	0	0	240	82		Government
Sershah engineering college	240	259	0	240	245	17	Government
Government engineering college	0	0	0	240	139		Government
Government engineering college	0	0	0	240	115		Government
Maulana azad college of engineering and technology	330	177	52	330	175	21	Private_Self Financed
National institute of technology	680	677	419	680			Government
Indian institute of technology	250	244	114				Government
Birla institute of technology	300	268	61	300	204	79	Private_Self Financed
R.p.sharma institute of technology	480	43	120	540	232	158	Private_Self Financed
Netaji subhas institute of technology, Bihta	600	196	200	600	224	78	Private_Self Financed
Bakhtiyarpur college of engineering	240	279	0	240	235	0	Government
Mother's institute of technology,bihta	240	3	0	180			Private_Self Financed
Nalanda college of engineering, chandi	240	264	14	270	265	2	Government
K.k. college of engineering & management	390	110	78	390	160	143	Private_Self Financed

[1] *Enrolment also include lateral entry*

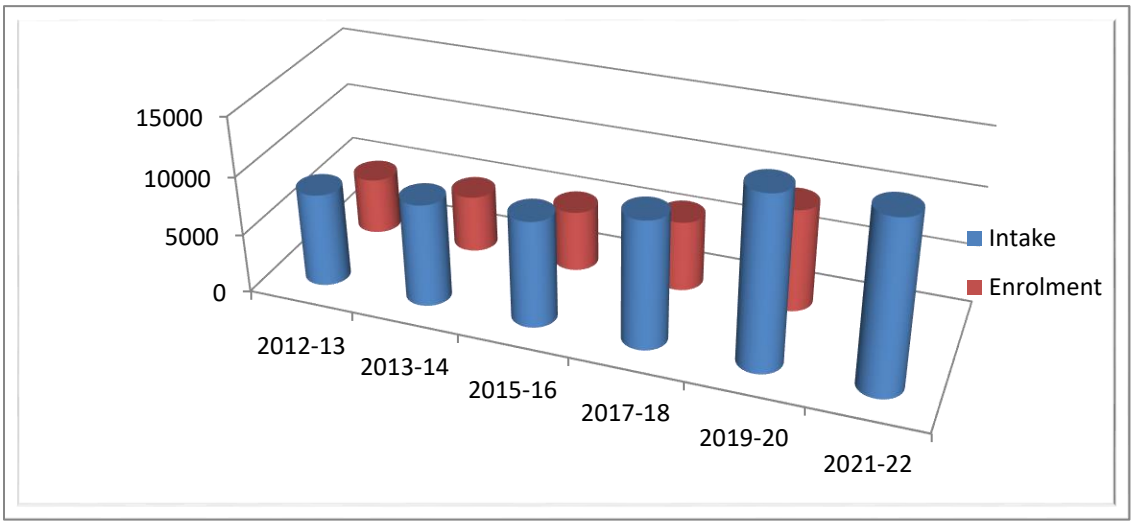
[2]*Placement data for the missing column were not available*

In the year 2020-21, the intake increased to 14918 with enrolment of 1223 girls and 6422 boys. The intake in most this in Bihar is 240 with traditional branches like electrical, mechanical, electronics and computer science and civil engineering. Highest intake presently in Bihar is 680 in NIT-Patna. The enrolment figure and capacity utilization is also not up to the mark, as discussed ahead. Among 57 engineering institutes in the latest year, there were 17 private financed institutes and rest was government (AICTE 2021). So, it showed less private participation in establishment of such institutes. With the check on quality and norms, Private players should be encouraged to open new engineering institutions. Government could provide concession in land allotment and other financial

helps. The public-private partnership model is required for establishing new engineering institution where quality infrastructure and education could be provided.

Even in the state of Bihar, the intake capacity under engineering education has almost doubled in last decade starting from 2011. The enrolment trend has also followed almost similar trend when growth line is seen. So, with increase in intake capacity, participation has improved. But, still, capacity utilization for the state is around 60 percent, which is double than national average for the year 2019-20 (based on data from AICTE 2021).

Figure 2.3: Intake Vs Enrolment under engineering education in Bihar since last decade



Source: AICTE dashboard

From the primary data, it was found that many government engineering colleges in Bihar lack even it's on building or basic infrastructure and presently running in the campus of other engineering college. Some of these colleges are Government Engineering College (GEC)-Arwal, GEC-Buxar, GEC-Sheikhpura, GEC-Jehanabad, GEC-Aurangabad etc.

Then, with respect to present number of engineering institutes in Bihar, there was mixed response with regard to need for opening new such institutes. Majority (54 percent) of the respondents believed that the state has sufficient number of technical institutes. But, around one-third of the respondent disagreed with this statement and believed that Bihar needs more number of engineering colleges. Then, the respondents were also asked about

the present intake capacity of engineering institutes in Bihar at all three level namely UG, PG and doctorate level.

Table 2.3: Response with regard to availability of technical institutes in Bihar (N=90, Data in %)

	S. Disagree	Disagree	Neutral	Agree	S. Agree
Sufficient_TI	21.1	14.4	10	30	24.4
Sufficient_Intake_UG	18.9	18.9	14.4	31.1	16.7
Sufficient_Intake_PG	43.3	26.7	12.2	14.4	3.3
Sufficient_Intake_PhD	54.4	26.7	10	2.2	6.7
Relevant_Disciplines	10	32.2	17.8	30	10
Rationally Distributed	11.1	17.8	16.7	28.9	25.6

Source: Primary data

Almost half of the respondents agreed that state has sufficient intake for engineering education at UG level. But, 38 percent of them believed that the intake at UG level needs to be increased. And 70 percent of them have responded that intake at PG level in engineering colleges in Bihar is not sufficient and it needs to be increased. The situation is worse at doctorate level. The state has very few seats at doctorate level. This is also reflected in the responses where more than four-fifth of the respondents have agreed that state needs more seats at PhD level and the present seats in engineering institutes in the region are not sufficient with respect to population of Bihar.

Then, respondents were asked about availability of relevant disciplines in Bihar. 40 percent of them have agreed that the state has all the relevant courses as part of engineering education. But, 42 percent of the respondents said that state needs to add more disciplines as part of engineering course. And when it comes to the distribution of engineering colleges in Bihar, merely 30 percent of them have said that the engineering colleges are not rationally distributed across the region. Almost, every district of Bihar has at-least one engineering college. This is also reflected in their responses, where 54 percent of them have agreed that there is rational distribution of engineering institutes in the region.

There is another view identified by respondents with regard to engineering education. Throughout country, enrollment in engineering education has reduced due to lack of jobs. So, rather opening new colleges, improving existing institutions through up-gradation of

infrastructure, faculty recruitment drive would be more effective. Quantity wise, there are enough engineering colleges in Bihar, but it is lacking quality wise. The quality here means in terms of infrastructure, laboratories, faculty-student ratio, discipline among students, environment of education in college and other such things.

Then with respect to preferred region for location of institute, Respondent believed that colleges should be distributed zone wise. Under-developed areas should be preferred. North Bihar is suggested by a Respected Dean of a public institute. Many respondents believed that the distribution of engineering institutes seemed fair. What is more worrisome is the quality of engineering education in different regions.

> Engineering institutes should be located at 200 km each.
>
> Administrative Officer, Male, Public Engineering Institute, Patna

Also, there is need for rational distribution of engineering infrastructure. The states like Bihar and North Eastern region seemed to have lower access of engineering education, as reflected in low enrolments. The low enrollment in higher education in the state is reflected through the Gross Enrolment Ratio for higher education in Bihar (14.5), which is almost half of all India average(27.1) (AISHE 2019-20).

So, more number of colleges is required in these regions. Due to insufficient number of quality higher technical institutions in the state, thousands of students are forced to migrate to other states, causing additional financial burden. But, even this option has its own constraints, particularly for girls, scheduled classes, students from rural settings and other SEDGs. Also, Bihar shares international boundary with Nepal. So, availability of more number of quality engineering institutions in the state could make it, the potential destination even for the international students which could then contribute in the development of the state. This theme is further discussed in section 2.4 of this chapter.

2.1.2. Availability of various disciplines and levels

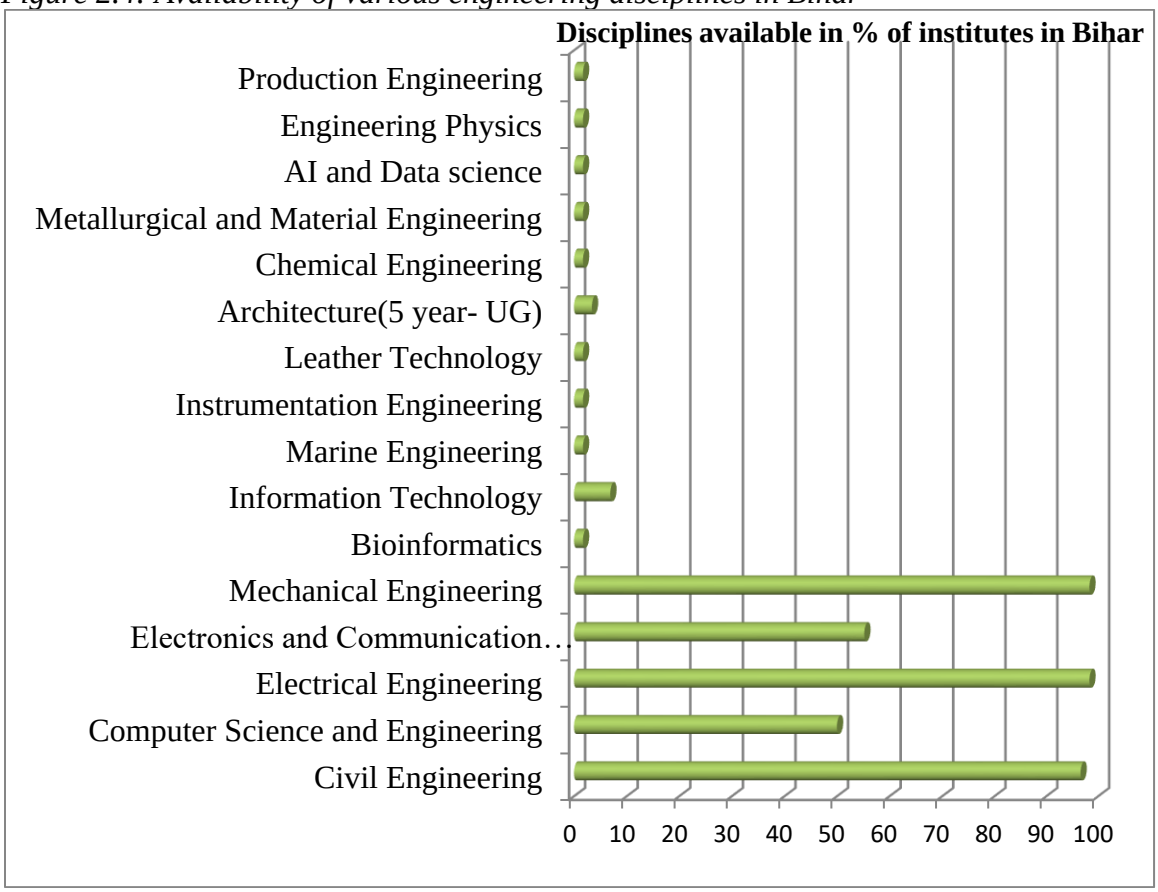
Engineering education is an ever emerging field. The traditional disciplines like Electronics engineering, Civil Engineering, Mechanical, Electrical, Computer Science and other such engineering discipline are important, but must also inculcate the changing demand of industries by including new emerging disciplines as part of engineering education. Today is machine age based on data. Data is believed to be the new currency. So, the educational courses should also be reformed accordingly. But, this process is found to be very slow.

At country level, top 10 engineering disciplines constituted 90 percent of the overall capacity and 50 percent of enrolment (AICTE 2018). But, the demand lies in emerging engineering discipline unlike the traditional courses. AICTE committee for short and medium term perspective plan for technical education, 2018 had observed that future engineering disciplines would be extremely different from the engineering streams of the present day.

For study purpose, the data of various disciplines available under engineering institutes in Bihar was analyzed. It is found that the present trend in engineering education in Bihar is not in very much sync with demand of the time. Only traditional and core branches are available in most of the technical colleges in Bihar. Civil Engineering, Electrical Engineering and Mechanical Engineering are the most famous branches available in more than 95 percent of the technical colleges of Bihar. Computer Science and Engineering and Electronics and Communication Engineering are next preferred branches which are available in around half of the technical colleges in the region. Then, Information Technology as a separate discipline is also available in very few colleges of Bihar.

Some of the emerging disciplines like Artificial Intelligence and Data science, engineering physics, Marine engineering, Leather technology, Instrumentation engineering, Production Engineering, Material Engineering and Bioinformatics are available in very few (1.7 %) colleges of Bihar. Architecture engineering as a discipline has also become quite relevant in the present times. But, this course is available only in less than 5 percent of the technical institutes in Bihar.

Figure 2.4: Availability of various engineering disciplines in Bihar



Source: AICTE (2021)

Now, when it comes to post graduation and further studies under technical education, there are only few colleges in Bihar offering PG and doctorate level technical education. The post graduation and doctorate degree under higher technical education is available in only 15.5% and 5.2% of the technical institute in Bihar respectively.

Table 2.4: Various existing engineering disciplines in Bihar at PG level

Civil Engineering	Computer Science and Engineering	Electrical Engineering	Electronics and Communication Engineering
Mechanical Engineering	Masters in Computer Applications	Machine Design	Micro Electronics and VLSI Technology
Thermal Engineering	Thermal Engineering	Power System	Urban and Regional Planning
Computational Mathematics	Civil and Infrastructure Engineering	Mechatronics	Nano Science and Technology

Communication System Engineering	Material Science Engineering	VLSI and Embedded system	

Source: AICTE (2021)

But, these disciplines are available in very few technical colleges in Bihar. At the same time, there is also lack of interested students for post graduate or doctorate level, since most of the students after graduation prefer to get job. According to one of the respondent, only one-sixth of students at graduate level think about enrolling for higher education. Never the less, seats needed to be increased. Emerging branches like VLSI, IOT etc. should be added at master level.

Another issue is the cost of pursuing post graduation, which is in range of 5-6 lakh. It is not affordable for economically weaker section. And when it comes to adding seats, mostly specialized courses should be added. Respondents believed that seat at post-graduate level seemed fair. But, more seats required to be added at doctorate level. At doctorate level, there is restriction from government on full time scholars due to fellowship constraints.

> At NIT-Patna, for example, only 2 Full time scholars are permitted in ECE branch. This could be increased to 4 at least.
>
> Faculty, Female, Public institution, Patna

At post graduate and higher level of engineering education, there is even more requirement of practical than theory. So, it would require extra facilities for labs and other infrastructures, apart from costly equipments. First, these facilities needed to be created at colleges, before increasing seats at higher technical education. But, even more challenging issue at hand is that the post graduate and doctoral students also needed to be absorbed. For such students, only teaching job is major job opportunity in the state. There is lack of much job prospects for them at industries in India. The hiring of doctoral candidates by core companies in India like Intel, Qualcomm, Samsung and others are very few.

Further studies on emerging disciplines are done in the section 2.3 on quality of technical education. But, there is need for creation of educational hubs in Bihar, like Noida industrial region in Utter-Pradesh, where large number of institutions was established in a

region in proximity. Similarly, in Bihar such hubs could be carved. Rajgir-Bodhgaya corridor could be developed as one such educational hub. Agglomeration of engineering colleges also attracts employers to visit for recruitment, since it provide them more choices in recruitment and facilitate effective utilization of time and money. And branded private engineering colleges (having better ranking) like SRM, VIT etc. should be invited to open their branches here.

It would create better environment of education and increase the exposure of students. The establishment of such colleges in Bihar would lead to inter college exchange programs and technical and cultural fests, which would enhance the exposure of students. It would create better engineering environment in the state and would also improve the quality of engineering education in both private and public institutions. For the professional training of rural youth, Industrial training institutes could be further enhanced.

2.2. Participation under technical education

The participation of students under higher technical education depends on various factors like availability of such institutes, its accessibility, affordability, awareness about such education and its prospects. Participation could be seen in varieties of ways like with respect to gender, SEDGs, minorities, region, class or caste etc. In this chapter, the participation is analyzed with the help of primary as well as secondary data. Table 2.5 showed that when participation under higher technical education was seen with respect to enrolment proportion as part of eligible population, then it comes out to be 0.06 % and 0.5 % for Bihar and India respectively for the year 2019. So, participation under technical education in the state of Bihar is much low in comparison to country average. So, the various issues in participation are being discussed ahead.

To begin with, the participation under technical education has large dependency on economic status of students. The students could be categorized into low income group (LIG), middle income group (MIG) and high income group (HIG). For LIGs, fee

affordability is a major concern. Hence, in general, there is low participation under higher education for such students. For MIGs, the participation is constrained in Bihar due to lack of availability of good engineering colleges in the region. Here, quality is more of a concern than quantity of engineering institutes. Then such students also prefer to prepare for government jobs rather getting involved under general higher education. For students belonging to HIGs, there is least concern with respect to participation. They have more choices to migrate and afford better quality technical education.

Thus, participation in higher education in general and engineering in particular is limited by financial constraints. Fee structure and hence affordability is a major factor for students while taking admission in engineering colleges. In general, government colleges are more affordable than private, so public institutions are likely to be preferred. Then, social factor of perception among parents and students about engineering degree is an important consideration while deciding enrollments. The image of 'Engineer Babu' is now changing but still relevant, particularly in rural areas of Bihar. Engineering degree is taken as better alternative in comparison of many other traditional degrees and degree in humanities. In this context, still students prefer to get enrolled under engineering education.

> Although, around 50 percent seats at engineering institutes remain vacant, never the less, still there is craze for engineering, since after pursuing it, student sooner or later get employed in some kind of job for livelihood. But, the suitability of these jobs as per engineering profession is debatable.
>
> Director, Male, Semi-government Engineering Institute, Patna

And since, affordability is major concern for economically weaker sections; it caused vacant seats in engineering colleges. The cost of education at NIT-Patna is around 6 lakh for B.Tech course of 4 years. IIT-Patna is also planning to charge somewhere around 10 lakh for the four year engineering UG course. Bihar government is facilitating educational loans through student credit card which has increased affordability of education to students and increased accessibility. But financial burden of pursuing engineering is quite low in Bihar in comparison to other states. So, economically weaker

students prefer to enroll in state government engineering colleges. Then, this is the perception among students, that in the industrial hub regions like Bangalore, Noida and other such places where engineering colleges are in proximity of companies, the employability is better. It is believed that even if colleges are not able to provide placement, the off-campus options could better be utilized.

Apart from it, the type of city (metropolitan, capital city etc) and tag (brand) of college also matters for participation of students. There is also craze among students of Bihar for government jobs which impacted the participation under engineering education. Now, when it comes to participation with respect to urbanization, it was seen that, in Bihar, urban student has fair enrollment under engineering education. But 88.7 percent of the population of Bihar is rural (Census 2011). For rural students, financial constraint is a bigger challenge. The access of education loan on agricultural land is less, which hampers the participation of rural youth under engineering education.

The other factors which affect participation or enrolment is the reputation of an institute. Then choice of branch (discipline) also matters. Even, locational advantage/disadvantage impacts the enrollment of students. Then, campus life is also missing for most engineering colleges in Bihar, affecting participation of youths under such education. Residential facilities, cultural fests, inter-college interactions and games are as necessary as providing quality education. Then, safety and security is also a factor of participation. NIT-Jammu is one such example where enrollment is affected by perception of safety among students. Then with regard to management type of institute, except IITs and NITs, for other engineering colleges, it is not a major concern for students.

> Ranking of NIT-Uttrakhand, a government college is less than many private engineering colleges. BITS Pilani compete with IITs.
>
> Administrative Officer, Male, Public Engineering Institute, Patna

So, management type per se, it does have much effect on decision making or choices of students while taking admission. Generally, government colleges are more affordable and hence attract students. Now, participation of youth under engineering education could also be studied with respect to gross enrolment ratio (GER). In general, GER for higher

education is less in India as a whole and Bihar in particular. “The aim will be to increase the Gross Enrolment Ratio in higher education including vocational education from 26.3% (2018) to 50% by 2035”(Government of India, 2020). To increase the gross enrollment ratio for higher education in Bihar from 14 percent to the national average of 24 percent and increase up to 30 percent, Bihar student credit card scheme was launched in 2016. Under this scheme, a loan up to Rs 4 lakh is provided to such students who could not otherwise avail higher education due to economic reasons (Government of Bihar, 2016). It has improved the participation of students in engineering education and particularly the participation of economically disadvantaged groups. The annual charge for Bihar state government engineering institutes is very low in comparison to other such institutes. For example, the development fee is only Rs 2500 per year and tuition fee is Rs 120 for a year (Government Engineering College Nawada, 2021).

But, in the state of Bihar, participation is not optimal in proportion to population. The reason is varied. But one of the reasons is the shift in trend of studying science. Now the number of students who is choosing commerce, business or other disciplines has increased, and hence the fate of engineering witnessed the shift. At the same time, the less economic return of engineering education is one major reason, affecting the participation. So, in order to enhance participation, the quality of education is foremost criteria which needed immediate attention and improvement. The issue of quality was discussed ahead.

2.2.1. Gender gap

Now, when participation was seen with respect to gender, then, it was found that there exist gender barrier even at all India level. The table below showed that the girl’s enrollment in engineering colleges is mere 30 percent at national average while it varies from 14.9 percent in Bihar to 40 percent in Andhra Pradesh. It points the need for removing gender barriers in engineering education by addressing the issues related with girl’s education.

> Participation of girls in engineering education is not up to the mark. In group of 30 students, there used to be only 4-5 girls.
>
> Faculty, Female, Public Engineering Institute, Patna

So, the situation is grave for girl participation at higher education. The family pressure is major issue with female students where continuation of education becomes a challenge, particularly after graduation or post-marriage. This situation is even worst for less developed states like Bihar. As per AICTE (2021), for the academic year 2020-21, out of total enrollment of 7645, the female participation in engineering institutions in Bihar was 16 percent. The corresponding figure for academic year 2019-20 was 8786 percent and 15 respectively.

Table 2.5: The gender wise data on Enrolment and population in Bihar and India

		India	**Bihar**
#Population (18-23 age) in 2019	Male	52%	53%
	Female	48%	47%
	Total	150805,000	14353,000
*Enrolment_Eng. or the AY 2019-20	Boy	70%	85%
	Girl	30%	15%
	Total	804060	8786

Source: Author's calculation based on data from AICTE (2021) and National commission on Population (2020)
#Data taken from population projection made by National Commission on Population
**Enrollment in Engineering Education at UG and PG level in Academic year 2019-20*

The above table showed that female participation in engineering education in Bihar is half than national average in terms of percent enrolment for girls. At the same time, the male-female ratio for enrolment is not in proportion to the population for the age group 18-23 cohort. In fact, the percentage gap between male and female in population for the age group 18-23 was 4% and 6% for India and Bihar respectively in the year 2019. But, this gap in enrolment percentage is 40 percent and 70 percent respectively for India and Bihar in the same year for engineering education.

The gender gap is also witnessed from the data presented in the table below. The overall percentage of female participation under engineering entrance examination in 2021 was merely 30 percent where as census 2011 enumerated around 48 percent female population. Based on report of expert committee on population projection (National Commission on Population 2020), the percentage population is calculated by the author. The projected female population for year 2021 in the 18-23 cohorts for all India level

comes out to be 47.6 percent. The same figure for Bihar was 47 percent. So, it showed lag of around 18 % in female participation under higher technical education.

Table 2.6: Gender and Category wise number of candidates registered for entrance to B.E./B.Tech. Course in February 2021

Gender	General	EWS	OBC	SC	ST	PwD	Total
Female	90522	18028	67181	15948	6092	330	197771
Male	196673	45372	154872	41626	16309	1448	454852
Transgender	1	0	1	0	2	0	4
Total	287196	63400	222054	57574	22403	1778	652627

Source: National Testing Agency (2021)

The same lag under female participation is also witnessed at level of entrance exam for getting admission in engineering courses. The above table showed that in 2021, the female participation under entrance examination for admission into engineering courses was 32% under General category, 28% under EWS, 30% under OBC, 28% under SC category, 27% under ST category and 30% in total. So, these figures pointed low participation of female students under higher technical education. Necessary steps needed to be taken to increase their participation in order to bring equity and inclusivity in higher education.

Supernumerary seats were created for increasing female enrollment at UG level in IITs, from eight per cent in 2017 to 20 percent by 2020 (Joint Admission Board, 2017). But, girl students often hesitate to move outside of their home city due to societal challenges. By increasing girl participation in engineering courses, they may emerge as female role model in such courses and motivates other girl students to participate in science and technology. Similarly at state level, to motivate the girl students towards higher and technical education, Bihar government had announced 33 percent reservation for girl students in engineering and medical colleges of the state (Government of Bihar, 2021). This has positive impact on participation of girls in engineering education. For example, the respondent from BIT-Patna campus has stated 40:60 ratio for female and male students. Such steps could be inculcated at national average.

Respondents also believed that, in general, girls were found to be more sincere in engineering education. But, their enrolment is low under technical education. The sex

ratio in Bihar was found to be 918 female per 1000 male in 2011 (Census 2011). But, this ratio was not duplicated in education and particularly low under engineering education.

> The female students' percentage under engineering education is around 10-15 percent in Bihar. It should be around 40 percent.
>
> Dean-Academic, Male, Public Engineering College

To improve the participation of girls in state government engineering colleges, the gender specific constraints needed to be identified and resolved. Safety and security and availability of basic amenities are major challenges for female students, particularly in government engineering colleges. The other gender related concern affecting participation is the job suitability for female technical graduates. Female students often do not prefer field jobs in industries. So, their participation in core branches of engineering like Mechanical Engineering, Electrical Engineering and others is not up to the mark. They prefer Computer Science and other such related branches. Although after creation of supernumerary seats, their participation has increased from earlier.

2.2.2. Participation of disadvantaged groups (SC/ST/OBC/EBC)

Now, when proportion of scheduled castes and scheduled tribes was seen among total projected population of India in 2021 under 18-23 cohorts, the figures are 16.78 percent and 8.4 percent respectively (Calculated based on report of expert committee on population projection, National Commission on Population 2020). But, it was witnessed from the Table 2.6, that the proportion of SC and ST students as part of all the students who registered for engineering entrance exam was merely 8.8 % and 3.4 % respectively in the year 2021. So, it pointed low participation of students belonging to disadvantaged group.

> "Access to engineering courses is particularly limited for students from poorer households. Even for those who are able to enroll, the challenge is not over, with specific groups such as students from scheduled castes and tribes and female students having lower transition rates from the first year to the second year, relative to other students, leading to higher dropout rates from students in this category."
>
> World Bank, Government of India, 2017

Their participation is improving in Bihar due to governmental subsidy in education. But now limited reimbursement of fee by government for engineering education (unlike earlier) is impacting participation of disadvantaged groups. The 10 percent annual fee hike is also putting financial burden on such economically weaker students and hindering their participation under engineering education. But, most respondents felt that there is no caste barrier in pursuing engineering education as such. The reservation of seats for disadvantaged groups has lead to their fair participation.

2.2.3. Locational impact on participation

The issue to be examined was, if location of engineering institutes impacts the participation or enrollments? Location of an institute is one major factor affecting enrollment or participation. Respondent provided example of NIT-Hamirpur and IIT-Mandi (both in Himachal Pradesh) have locational disadvantage of hilly terrain. So connectivity is poor and impacts participation. Similarly, the rural location of an institute distracts students. Location impacts the number of recruiters who visit the college. Capital city or better connected location of an institute attracts more recruiter in comparison to poorly connected recruiter. The same also affect the participation of students.

It was found that central location of an engineering institute in proximity with police headquarters ensures better discipline among students in colleges. The interior location of an engineering college in general, makes the task of administration challenging to ensure discipline in college. The lack of discipline cause deterioration of educational environment and motivates corrupt practices among students. Location within state or district matters more for female students. It certainly improves the access of engineering education.

The interior location of engineering institutes in Bihar also impacted enrollment. It was a reason that many a times, students preferred to move out of state where connectivity is better. Location within own district is not a major factor impacting participation in engineering education. Within state, movement is not a concern for students for education purpose. But, connectivity and availability of basic amenities are certainly a factor for increasing enrollment in engineering colleges. For example, Bangalore-Patna direct flight

could attract employer to Patna but not to other remote cities in Bihar. But, location within the district or division is a factor for economically weaker students. It improves the affordability of engineering education. So, location in general may not be a crucial factor but combined with other factors, become an important consideration which affects participation of students under higher technical education.

> For example, BHU has better location but seats of IIT-Patna are filled earlier because of better result.
>
> Administrative Officer, Male, Public Engineering Institute, Patna

2.2.4. Quantifying the relation of participation with college density, type and placement

The participation could also be understood with help of quantification of its relationship with existing number of colleges, their management type, the placement rate of the engineering graduates and intake. So, the dependent variable *partcptn_rate* was regressed on predicting variable *college_densty* and *placement_rt*. First correlation was ascertained.

Table 2.7: Correlation among variables namely participation, college density and intake

Variables		**Collg_Densty**	**Placement_Rt**	**Intake_pT**
Partcptn_rate	Pearson Correlation	.932**	.539**	.985
	Sig. (2-tailed)	.000	.002	.000
	N	29	29	29
Collg_Densty	Pearson Correlation		.569	.954

Source: Primary data
*** Correlation is significant at the 0.01 level (2-tailed)*
College density, placement rate and intake per thousand were shown under Table 2.1 and figure 2.5

There should not be multicollinearity among independent variables. The most accepted rule is that the independent variable should not correlate strongly with correlation coefficient more than 0.7. And the dependent and independent variable should have correlation coefficient of more than 0.3. As expected, there exist multicollinearity among college density and intake capacity, so Intake_pT was discarded as independent variable.

The correlation coefficient between participation of students in engineering education and number of college per lakh eligible population came to be 0.932 which showed very high correlation. And the correlation between participation rate and placement rate was 0.539 which represented the moderate correlation. The p value is less than 0.05 which showed the result is significant.

Table 2.8: Model Summary and ANOVA for the analysis of participation

R	R Square	Adjusted R Square	Std. Error of Estimate	F	Sig.
.931	.867	.857	2.24254	84.7	.000

Source: Primary data

The F value of 84.7 at significance level less than 0.05 indicated that independent variable played significant role in predicting the response. R value represented the correlation among the predicted and observed values. Predicted value is the value obtained from regression equation. The R square value showed that model explains the 86.7 percent of the variance in Partcptn_rate.

Table 2.9: The coefficients of regression of participation with college density and placement rate

	Unstandardized Coefficients			
	B	Std. Error	t	Sig.
(Constant)	-1.728	1.361	-1.269	.216
Collg_Densty	2.930	.279	10.499	.000
Placement_Rt	.012	.035	.352	.727

Source: Primary data

So, the regression coefficient of 2.93 for college density with significant result reflected that it has large impact on participation. The placement rate has regression coefficient of 0.012 and significance value more than 0.05.

Regression for data specific to Bihar

At state level, role of management type of each college was also incorporated in the regression analysis. The data was represented under Table 2.2. The *enrolment* is taken as dependent variable and predictors are *intake, placement and type.* The type variable

represent management type of institute is categorical variable with 0 taken as private self financed and 1 as government.

Table 2.10: Model Summary and ANOVA for analysis of participation, for the data specific to Bihar

R	R Square	Adjusted R Square	Std. Error of Estimate	F	Sig.
.872	.761	.747	63.3	57.2	.000

Source: Primary data

Table 2.11: Correlation of participation with management type, intake and placement for the data specific to Bihar

		Enrolment	Type	Intake	Placement
Pearson Correlation	Enrolment	1.000	.196	.588	.440
	Intake	.588	-.568	1.000	.588
	Type	.196	1.000	-.568	-.219
Sig. (1-tailed)	Enrolment	.	.070	.000	.000
	Intake	.000	.000	.	.000
	Type	.070	.	.000	.050
N	Enrolment	58	58	58	58

Source: Primary data

The above table showed that there is not strong correlation (multicollinearity) among independent variables. Also, the correlation of dependent variable *enrolment* with independent variable *type* is very low (0.196) while correlation with *intake (0.588)* and *placement (0.440)* is moderate correlation. So, the regression coefficients came out as follows:

Table 2.12: Regression of Participation with management type, intake and Placement for the data specific to Bihar

Model	Unstandardized Coefficients			
	B	Std. Error	t	Sig.
(Constant)	-189.307	27.165	-6.969	.000
Type	214.204	22.526	9.509	.000
Intake	.812	.078	10.376	.000
Placement	.012	.164	.074	.942

Source: Primary data

Thus, the above result confirmed and quantified that participation has significant relation with management type and intake and non significant relation with placement rate. The data at state level incorporated management type which has regression coefficient of 214.2 with statistically significant result. So, it concluded that availability of HTIs within

a region has paramount impact on increasing participation of students under higher technical education.

2.3. Quality of Technical Education

"Our engineering education needs to effectively cater to the needs of millennials and centennials, who have low attention spans, and expect flexibility in learning" (AICTE 2018). The engineering education is moving towards student centered learning. In this shift of education programs, quality of technical education is as important a concern as the quantity of such institutes. And there are varieties of ways to study quality. The ongoing section has analyzed the quality issue with respect to employability of technical graduates, engineering syllabus vis-à-vis industrial demand, availability of resources like infrastructure, faculties, research avenues and other qualitative aspects.

> "It is easier to find an engineer than a plumber."
>
> Dean (R &C), Male, Government Engineering College, Patna

Government of India assisted by World Bank started Technical Education Quality Improvement Programme (TEQIP) in 2003 to improve quality of engineering education (World Bank, Government of India, 2017). The third phase of TEQUIP started as central sector scheme continued in the period 2017-21 to support around 200 engineering institutes across India with focus on low income states and special category states. It aimed to produce more quality and employable engineers while focusing on states with under-performing engineering education system. The 18 focus state included Bihar.

TEQIP-III funded activities for training faculties and staff, investment in hardware and software, improving non-cognitive skill of students, sustainable faculty recruitment plan in select states and other such measures to improve quality of technical education. TEQIP led to improvement in quality and equity in engineering colleges in these focused states and particularly helpful in institutes located in rural settings. For sustainability of such

projects, steps should be taken at state level to restart such projects periodically for improvement of quality of engineering system at institution level.

2.3.1. Employability of engineering graduates

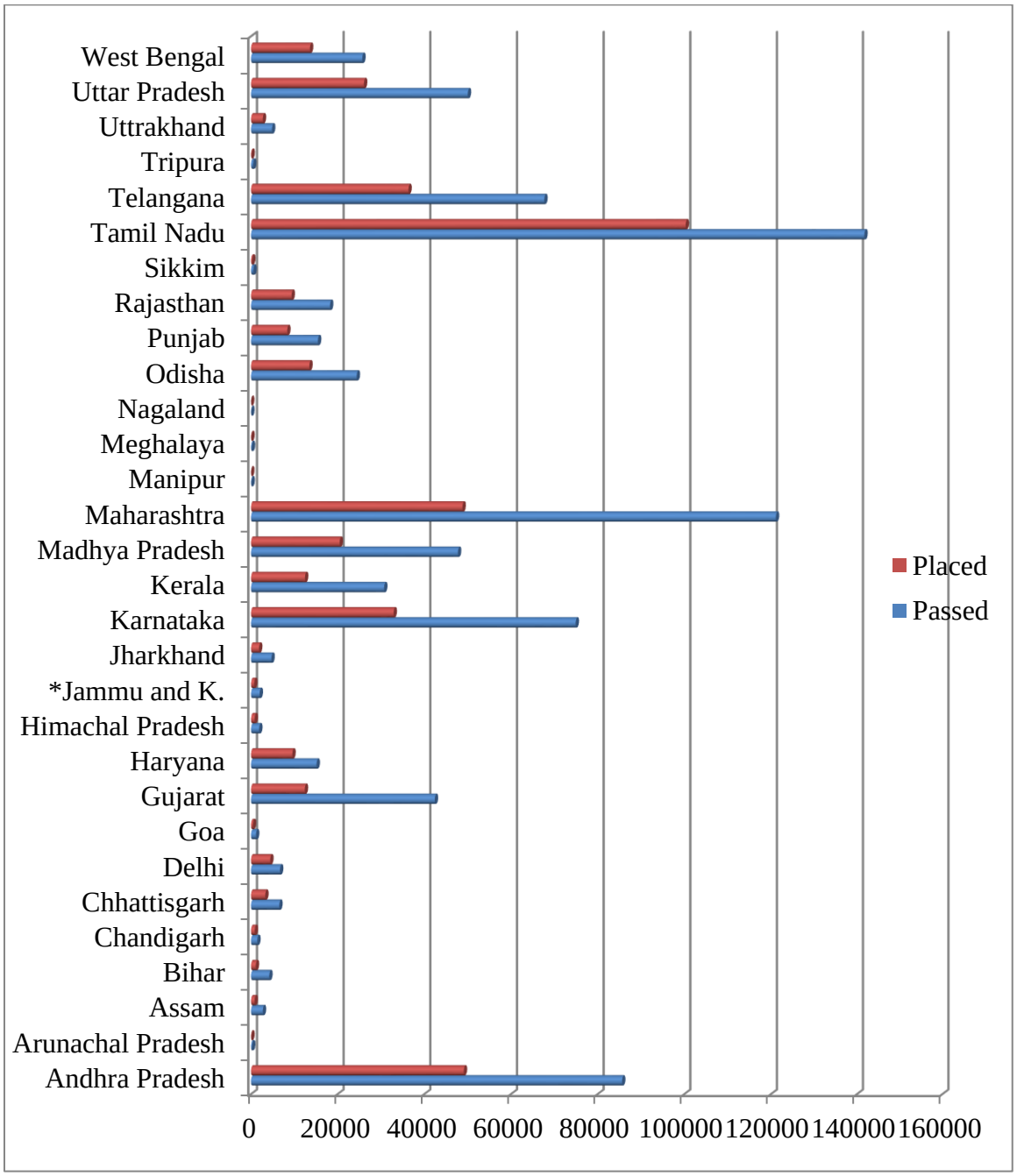
> At NIT-Patna, computer science (CS) branch has 200 percent placement rate. In the same college, in Electronics and communication branch, placement rate is around 90 percent. So, CS branch attracts engineering students more for enrollment.
>
> Faculty, Male, Public Institution

Employability is often an important manifestation of quality of education. Measuring employability is a tedious and complex task. The whole landscape of talent is changing in 21st century. So the employability of engineers got redefined as per new industrial needs. There could be varieties of ways to measure employability. Placement rate is one such figure which reflects employability to a large extent. Based on data from AICTE (2021), the placement rate for each state for the year 2018-19 was calculated. As we see the placement rate of each college, some insight for employability of passing engineering graduates could be developed. The placement rate at all India level was found to be 51.3 percent for the academic year 2018-19.

So, around half the passing engineering graduates were not employed as they pass from the college. The highest placement from engineering college was from Tamilnadu (70.8 %) which pointed towards more employability in the state for graduating engineers. In this context, the lowest employability for engineering graduates was found in Nagaland (14.9 %). The placement percent for graduating engineers in 2018-19 for Bihar (26.2) was approximately half than national average.

The states/UT like West Bengal, Utter Pradesh, Uttrakhand, Telangana, Tamilnadu, Odisha, Haryana, Delhi, Chandigarh and Andhra Pradesh has placement percent better than national average. But other remaining states performed worst in terms of employability of passing engineering graduates. Manipur and Nagaland are two worst performing state in the north-eastern region for employability of engineers, where less than 16 percent passing graduates were placed in 2018-19.

Figure 2.5: Diagram showing number of students passed and placed from engineering colleges located in different states of India



Source: Based on data from AICTE website for year 2018-19 for each state and UT except Mizoram

** State of Jammu and Kashmir was bifurcated into two union territories namely Jammu and Kashmir, and Ladakh on 05.08.19*

Placement Rate = (Number of student placed/ Number of student passed)*100

Employability is a dynamic concept. It is unique to a person which makes him/her more competitive with respect to others. The skill requirement for the same job profile keeps changing with time. So, the employability framework should be developed in collaboration with industries and should be made part of the curriculum of four year engineering courses. To increase the credibility of employability report, the formal employability study should be done by government agencies in collaboration with industries. It also needs to be seen from both demand and supply side. The supply side barrier is particularly a concern for state like Bihar. What are the criteria for visit of employer to a particular college or region is a matter of further inquiry.

"The poor employability of engineering graduates is reflecting poorly on the faculty shortage and quality, and pedagogy (AICTE 2018)." So, there is pressing need that the engineering curriculum must be designed in sync with changing skill needs. The whole course must be connected with each individual course of previous and future semester. The engineering graduates of 2022 are facing different challenges and competition than earlier times. New set of competencies and skills are required to become employable in world of work.

A recruiter test students in three rounds namely, personality test, knowledge test and HR (Human Resource) interview round. So, apart from focusing on technical knowledge, personality development should also be taken care through extracurricular activities. Development of communication skills is one of the concerns for most students in Bihar engineering colleges, particularly for students belonging to rural settings.

Many times, the faculties in many engineering institutes, themselves are not exposed to new development in industries or new techniques or software, so they do not even demand such new things from administration and quality of education suffers. Frequent talks with industries and webinars should be organized at all engineering colleges. It would provide exposure towards the needs in the market and suitable action should be taken based on input. Mini projects in every disciplines based on all possible important topics should be performed to provide practical view of real engineering scenario.

These things were lacking in most engineering colleges in Bihar. Students should also participate in faculty development programs to learn new things. They should be

motivated to utilize the digital and alternative learning platforms like MOOC, NPTEL, SWAYAM and other such platforms. Then, the last semester project has become formality in many engineering colleges. There should be industry linked projects through signing of MoU between institute and industries.

It would facilitate innovation and creativity among engineering students and would lead to creation of new start-up ventures. In many engineering colleges, there is lack of proper initiative to interact with industries and even in calling them to college for placement drive. There is also need to assign more weightage to communication linked courses in curriculum. Also, there found concern for lack of discipline among students in many engineering colleges in Bihar. Regular classes and discipline among students are important steps to improve quality of engineering education in the state.

Now, when employability issues are examined particularly at state level for Bihar, then there emerged some different peculiarities. Inter-college and international student exchange program enhances the exposure of students and enhances employability. But, such organization of inter college tech fest and cultural program in most of the Bihar engineering colleges was lacking. Lack of industries in Bihar is also a reason for low employability of engineering students and is a concern for quality education. There should be focus on training of students for job oriented market. So, there is need for enhanced industrial exposure during course transaction in engineering education. The practical training many times is found unsatisfactory in engineering and technology domain. The industries need to be involved in such trainings as part of curriculum.

Bihar has also an issue of green land which could not be transferred for establishment of industries, as per the law. Such rules needed some changes to accommodate land requirement for industries in the state. The opening of industries would also enhance employability of engineering graduates and would complement the quality of engineering education in the region.

At the same time, very few companies visit the state for placement in comparison to other states. Also the education environment is different in other cities outside Bihar. So, students prefer to move out of state for expectation of better socio-cultural and educational exposure. In the National Institutional Ranking Framework under

engineering category, only two engineering colleges featured among top 200 engineering colleges of India, which are IIT Patna with rank 21 and NIT-Patna with rank 72 (National Institutional Ranking Framework, 2021).

Also, the lower fee although increase affordability but it has own repercussions on quality of education and infrastructure developments. Respondents have strong reservations against it. They felt that such a low fee for an engineering institute is non-sustainable. The admission in engineering colleges even at much low rank of students in merit list is also a major concern for quality of engineering education.

India, being the second most populous country in the world and lying within the list of top 10 world economy, the engineers could be termed as 'backbone' of the nation. So the accessibility and employability of engineering education is a matter of paramount importance. The step should be taken to enhance employability of engineering graduates. The placement rate of passing engineering graduates must increase to attract students in engineering education. The increase in employability would also affect accessibility of engineering education, indirectly by attracting investment and student's interest and motivation.

There should be performance review committee for check on quality of engineering education. The students after graduation are more interested in job. One respondent said that hardly 10 percent students are interested in research and merely half of them are true researcher. Others were enrolled under research, merely in absence of job.

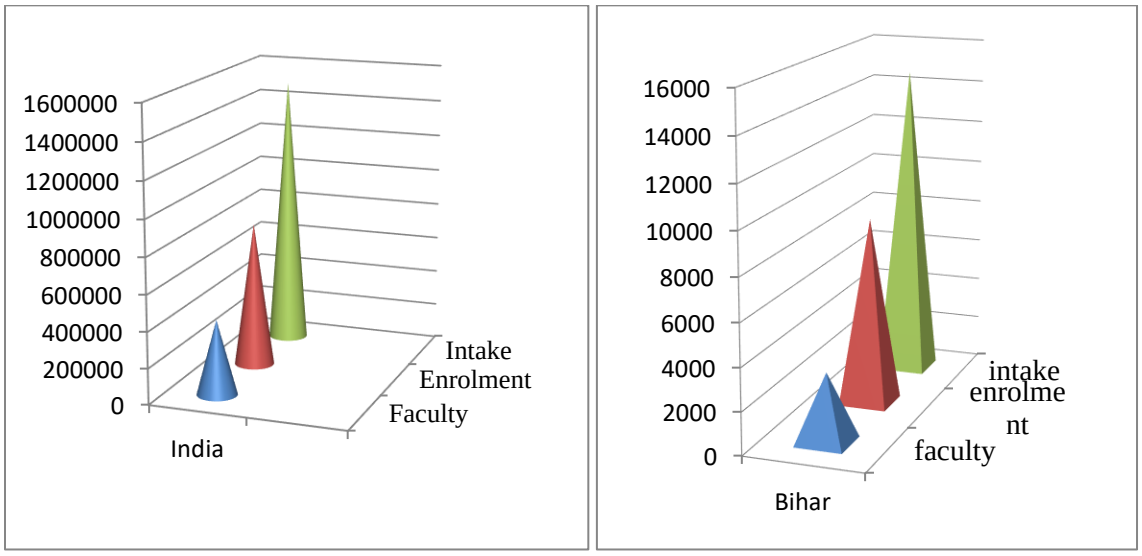
2.3.2. Lack of qualified faculties

As per AISHE (2019-20) the people-teacher ratio (PTR) at all India level comes out to be 26 for all types of institutions. The PTR is more than 50 in Bihar while Karnataka and Tamilnadu have best PTR of 18 each. This scenario of PTR in engineering education was also worse in Bihar. It was found that the poor ratio of Faculty and students even in old colleges like MIT, NIT-P and others is a concern for quality education and students prefer to choose colleges outside state.

> "There is dire need to improve the teacher-student ratio. The actual ratio on ground in Bihar is around 1:50 in comparison to 1:4 in developed nations. Such ratio should be enhanced to at least 1:10."
>
> HoD, Male, Semi-government Engineering Institute, Patna

Now with the recruitment of contractual faculty, the ratio is improving, but situation is grave in private engineering colleges. So, many students move to Pune, Bangalore, Asansol, Calcutta, Durgapur and other such cities, outside Bihar. The faculty student ratio among engineering institutes for the country with respect to intake in academic year 2019-20 was 1: 14.3 while same for Bihar was 1: 18.2 (calculated based on data from AICTE 2021).

Figure 2.6: Diagram showing Faculty, enrolment and Intake in engineering institutes for the academic year 2019-20 at UG and PG level, in India and Bihar



Source: Based on data from AICTE (2021)

As this faculty-student ratio would improve, the load on faculties would reduce. So, they could assign weakly task to engineering students like minor projects which are application based and could better supervise them. Hence, it would improve the quality of technical education.

There is another issue with temporary teachers in colleges. Many guest faculties are not motivated enough to get connected with the institutes and for better educational environment in college. The guest and contract faculties quickly switch to other college for better opportunity. Their constant search of better career option and temporary job nature makes them instable and impact their educational services.

2.3.3. Brain drain due to lack of quality

An engineering students move out of state for admission due to varied reasons. It may be his/her preference to migrate or lack of choice in the state for quality technical education or infrastructure deficit. The expectation of better placement and exposure to better environment for engineering education also pushed the students to shift to other states. The perception of better quality education and better facilities outside Bihar is also a factor for students, preferring to get enrolled in colleges outside states. But, brand of college, for both private and government influence the decision of students while choosing college.

The lack of discipline among students in many engineering colleges of Bihar is also a factor for migration of students outside Bihar. Respondent suggested that many high income families from Bihar have settled outside states and so they get enrolled their children there. Once, a person move out of state, some return back and others permanently stay there and start contributing in the economy of the place of the destination. And thus, many a times it led to the phenomenon of brain drain from Bihar.

2.3.4. Emerging Engineering Disciplines

Technical education is ever evolving field where technological changes are occurring at a fast pace. So, engineering disciplines should be in sync with the changing needs of the industries. The need of the hour is to inculcate multidisciplinary subjects in curriculum as highlighted by NEP 2020. One respondent quoted that IIT-BHU have started Mathematics and computing branch (MAT) which imparted the knowledge of numerical and computational methods. Similarly there is AI and Data Mining discipline which combine the domain of Artificial Intelligence and Data Mining. Other such example is IIT-Patna which offers M.Tech program in Mechatronics, combining some topics of Mechanical engineering and Electronics and Communication engineering. Such innovative combinations enhance interest of student and at the same time more relevant as per needs of the industries.

So addition of more number of non-conventional branches is awaited like hydrology, nanotechnology, biotechnology etc. This is the era of machine learning. So, seats should be decided keeping this in mind. Similarly, seats may be added in cyber technology, Block chain technology, IoT, AI or data analytics branches. Lot of elective subjects should be added to core branches to enhance their suitability to the present needs in the society and market. Like python language, electromagnetism, software define radio (SDR), environmental engineering, Informatics, GIS, Remote sensing, AutoCAD etc. could be added as elective subjects as per the market needs.

Even new combination of branches could be created as per the local needs. For example, for agriculture based economy of Bihar, agriculture engineering and related courses may be having more relevance. And even, such startups could be encouraged in engineering institutes in the region. Similarly, in Hyderabad region, electronics based courses and start-ups should be encouraged through engineering colleges. Credit based choice system gives flexibility to include minor courses or specializations under main core course.

> BIT-Patna offers Electronics and Communication Engineering degree with minor in computer Science. Under this system, 18 credit of CS branch is taught to ECE students.
>
> HoD, Male, Semi-government Engineering Institute, Patna

Such flexibility and interdisciplinarity should be encouraged in modern time of mixed approach and the need of having aided exposure. Interdisciplinarity involves acquisition of knowledge of two or more academic disciplines into one activity. In today's interconnected world, basic knowledge from several other fields like sociology, anthropology, psychology, economics etc should also be inculcated in modular and credit forms, along with the technical core subjects.

Often, seats are going vacant in many branches of engineering but the removal of any branch of engineering is not a solution. Every discipline is relevant and required. All disciplines are needed to provide engineers in that field. Rather, intake may be decreased for those branches where seats are going relatively more vacant in last decade. The

intake of some traditional disciplines may be reduced based on proper analysis. The state also needs some new engineering disciplines which lacks in Bihar.

> Nalanda College of engineering proposed to start Aeronautics engineering branch.
>
> Faculty, Male, Public Engineering Institute, Patna

Another such example is that, at NIT-Patna, there are five specializations in Civil Engineering branch. These are Transportation engineering, Geotechnical engineering, Water Resource Engineering, Environmental Engineering and Structural Engineering (NIT-Patna website, 2021). Such steps should be encouraged for better motivation of students towards non-traditional branches of engineering. It would also increase student's participation in engineering education. So, such innovative courses need to be replicated in other engineering colleges of Bihar.

Agricultural engineering and related courses like food processing, dairy and animal husbandry, fisheries related technical courses could be potential employment based disciplines in Bihar engineering sector. Silk technology, textile technology has large potential in Bihar. But, unfortunately Bihar institute of silk and textile at Bhagalpur has been closed for a long time. Ethanol blending Technology is another such sector which has potential to reduce emission from transportation and agriculture and needed for sustainable development. With launch of Ethanol Production Promotion Policy 2021, Bihar became first state to launch its own ethanol policy and permitted ethanol production from all feedstock permitted by National Policy on Biofuels, 2018, which was earlier restricted to only sugarcane (Government of Bihar, 2021).

Then drone technology and anti-drone technology is getting increasing importance day by day. It is being used in plethora of sectors from agriculture to health and disaster management to defense sector. Recently demo of drone technology for agriculture in Bihar initiated at Begusarai. Architecture engineering (AE) is another discipline which needs promotion in the state. The status of AE should be recognized at government level through creation of public employment. Its recognition is important in the state due to requirement of large infrastructure creation in Bihar. Every municipality needs an

architect and town planner. But, presently in place of architect engineer, mostly people from different background are hired as an architect.

2.3.5. Engineering Syllabus

The syllabus is the backbone of education system. It is the base on which knowledge lies and the framework which guide mentor and mentee on the path of knowledge. The syllabus needs to be periodically revised as per the changing needs of the industries. There is urgent need to update the syllabus particularly for institutes under state government universities. One respondent said that many a time, only modules are changed in name of syllabus, and hence engineering syllabus are now same for more than 30 years now. The static syllabus is also a challenge for setting of new questions for exam over the years. So, the questions in the engineering exam for the same old syllabus start getting repetition and lead to guess work among students.

Then, the frequency or the period of the revision could be different for different branches. For example, the period of revision in syllabus for mechanical and Information technology branches could not be same. The revision could be done on quinquennial basis. But most respondent believed that syllabus should be revised periodically after 3-5 years. Now, who should be the authority to revise the syllabus? First of all, this work should be largely delegated to university itself to inculcate the local needs of the market. The authority to update the syllabus could also be a committee consisting of professors, researchers, representative from industries and other such experts. Such committee should be formed at university level. Feedback should be taken from students and parents. For this purpose, Board of Studies should meet at fixed interval to decide the need of market and modify the syllabus accordingly. Such board should have wide representations from all the stakeholders as mentioned above.

2.3.6. Other issues in quality technical education

There is also a tendency among many students in Bihar to get enrolled in engineering college of the state for the sake of degree. It is found that they actually prepare themselves for government competitive exams like Commission exams, exams of PSUs and other government job and neglecting the engineering syllabus. They are able to

receive engineering degree by studying in just last few weeks before exam, since many questions in exam are repeated from previous years. Thus, they receive engineering degree but actually lack the engineering concepts and this deteriorate the quality of engineers being produced.

There should also be check on capitation fee demanded in many engineering colleges. It violates the values and principles on which education as an occupation is based. Education services as a business model should not be treated like other economic activities. The capitation fee leads to corruption and unethical practices in education and thereby impacting employability and quality of technical education. The culture of education is also a factor. The engineering institutions in south Indian states charge more money for education in comparison to other states like Bihar. But at the same time, apart from making profit, they also periodically upgrade infrastructure in terms of buildings, libraries, campus. This culture seems lacking for most engineering colleges in Bihar. At the same time, private participation in Bihar is less for establishment of quality education for engineering.

Then other issue in maintaining quality education is regular knowledge gain and discipline in institution. The compulsory attendance among state engineering colleges along with disciplines among students needs to be inculcated as part of education culture. In last decade, the engineering colleges have witnessed the rise of student politics like in colleges where humanities courses are taught. The entry of politics in engineering colleges among students is impacting the environment and culture of education. Engineering subjects are not at par with political science or other arts subjects as far as student politics are concerned. The steps should be taken to regulate such activities in engineering colleges. It sometimes possesses safety and security challenges for faculties and de-motivates them from joining colleges in Bihar.

Then there is also need for regular update of various softwares used as part of technical education. There is lag between what students learn in class and what is actually being used in industries. This gap should be minimized and if possible, it should be zero. The perpetual license for software is on average around 15 years which also needs to be reduced to inculcate the industrial dynamism.

Moving further, there are many barriers to engineering education like financial barrier, infrastructure barrier, and gender or caste barrier among others. Engineering education has become a costly affair. So, it invites the need for further funding in engineering education. Recently, AICTE permitted to conduct B.Tech programmes in 11 native languages namely Hindi, Marathi, Tamil, Telugu, Kannada, Guajarati, Malayalam, Bengali, Assamese, Punjabi and Odia (PIB 2021). This decision would be a milestone in reducing language barrier and hence would increase accessibility of engineering education. So, 14 engineering colleges across 8 states decided to offer engineering courses in regional languages in select branches from the new academic year.

In a survey of AICTE conducted in February 2021, 44 percent students voted in favour of studying in their mother tongue. AICTE collaborated with IIT Madras to translate SWAYAM's courses in eight regional languages (Naidu 2021). Learning in the mother tongue is expected to increase not only the outcome but overall development. It would also build self esteem and self identity. For example, in South Korea, nearly 70 % of the universities teach in Korean and in Germany, more than 80 % of all masters' programmes are taught in German, even as they aspire to create their own space in global market (Naidu 2021). But, the majority of professional courses in India are taught in English language.

Then, lack of infrastructure is a pressing issue, impacting quality of technical education. In some government engineering colleges, there is no academic block. Classes in few engineering colleges are running in labs due to lack of infrastructure.

> In the present campus of Nalanda College of Engineering, three engineering colleges are running which include Government engineering college, Nawada and Government Engineering College, Sheikhpura.
>
> Faculty, Male, Public Engineering Institute, Nalanda

Their permanent campus is in making. But, it impacts the quality of engineering education. At the same time, it also de-motivates the students for enrollment in such colleges. The colleges where quality of education is better and where most students are

able to get placement after completing their engineering degree, seats still does not go vacant. It emphasizes the need of quality engineering education.

2.4. International border as an opportunity

Bihar has legacy of hosting ancient world famous Nalanda University. The state shares international border with Nepal. It is also in proximity with Bhutan, Bangladesh and Myanmar apart from east and south Asian countries. The lower fee for technical education in Bihar in comparison to other state could become an advantage, if education standards are maintained. So, the state has potential to become hub for engineering education even for foreign students, if quality technical education is provided. But various steps would be required to utilize this opportunity towards improving quality technical education. Respondents felt that Bihar definitely has the potential. But for this, first environment of professional education needs to be created in the region.

AISHE (2019-20) pointed that total number of foreign national students enrolled in India is around 50,000 from 168 different countries across the globe. And programme wise, B.Tech. is on the top with 19 percent of total foreign students. Among foreign students in India, B.Tech programme has highest (9503) enrolment, more than double the enrolment in program (B.Sc.), which is having second highest enrolment. Then, among all the courses, Nepal has highest share of 28 percent while Bangladesh and Bhutan has share of 4.6 percent and 3.8 percent respectively. Nepal, Bangladesh and Bhutan which are in proximity of Bihar, represent the top 4 countries among total foreign students enrolled in India. But on the contrary to geographical proximity, Bihar has merely 80 foreign national students (0.3%) while Karnataka has highest around 8000 such students. Thus if quality technical education is provided in Bihar, then it has all the potential to attract not only students from all over India but also foreign nationals.

To make Bihar as education hub, first, there is need to improve the quality of engineering education here. The qualified faculties should be recruited. Many retired faculties of Bihar who served in different parts of country and abroad should be encouraged through

proper incentives to serve in Bihar and share their experiences in college. Many times the interior location of college distracts qualified faculties to give their service there. But such retired faculties belonging to local areas would find it better to serve in such remote locations.

> Bihar has potential to attract foreign students and become educational hub. The burning example is BIT where students from Nepal, Sri-Lanka, Botswana, Tanzania and other countries are enrolled. Even name of hostel in BIT is Tanzania hostel. Bihar has legacy as well as environment. Only right attitude is needed.
>
> Director, Male, Private Self-financed Engineering Institute, Patna

Even in state government engineering colleges, there is dearth of faculties which need to be fulfilled. Here, a principal is in charge of more than one engineering colleges. There are very few associate faculties in the HTIs. At the same time, there is paramount need of attitudinal change among faculties, non teaching staffs and students about their duties towards the institute and the state. On one side, the extra endeavor would be required from faculties' side for improving the engineering education in Bihar. On the other hand, students also need to be disciplined towards studies and to the teachers and should value the system and culture of engineering education. The teachers needed motivation for teaching and improving the system of education as whole in Bihar.

Some remarkable steps have been taken by Bihar government in recent years for improving education. Bihar has allocated 19% of its total expenditure for education in 2021-22. This allocation was higher than the national average allocation of 15.8%, for education by all states (Bihar budget, 2021-22). It also allocated Rs 110 crores towards the establishment of new engineering colleges. But, to improve the quality of engineering education, continuous and sustainable investments required. Public-Private participation and joint- institutions could be a way forward.

If facilities in engineering colleges and connectivity are improved, with the opening of industries, the demand of engineering education would rise and it could further attract students from outside Bihar and even foreign students. In near future, it may appear as too ambitious dream to develop Bihar as an engineering hub of India, but if Bihar keeps

improving its engineering education and ascending, then in next 15-20 years, it is not an impossible dream.

The memory of past recent decades of Bihar is slowly getting replaced with ancient legacy of Bihar. Steps should be taken to accelerate this process to make Bihar again a hub for education and particularly engineering education. Faculties also need constant motivation and incentives to work better and put additional efforts. Non technical persons should not be made in-charge (principal) of engineering colleges as it creates tussle within the institute and hamper technical education.

There are some good examples available in the state in this regard. NIT-Patna has signed MOU with ISRO for setting up of regional academic centre for space. It also launched a programme on entrepreneurship, incubation and innovation (NIT-Patna website, 2021). Such initiatives should also be encouraged at other engineering colleges in the region. Industries needed to generate employment for engineering graduates of the region. The state engineering colleges should be connected with world class universities and initiate exchange program with them. There is need of establishing manpower and infrastructure in other nations. More research needs to be promoted and research funding should be increased. The concept of Joint Institution could be utilized with IITs. For example, IIT-Kharagpur is in proximity which could be linked with state government engineering colleges.

Another such example is the University Grants Commission (Academic Collaboration between Indian and Foreign Higher Education Institutions to offer Joint Degree, Dual Degree and Twinning Programmes) Regulations, 2021. It introduced the concept of credit recognition and transfer, twining arrangement, joint and dual degree programmes (UGC 2021). Under the concept of Credit Recognition and Transfer, Credit conferred by a foreign higher education institution is to be recognized, quantified and included towards the credit requirements for a programme delivered by an Indian higher education institution solely or jointly with a foreign higher education institution and vice versa.

Then under twinning arrangement, students enrolled with an Indian higher education institution may undertake their programme of study partly in India and partly in the foreign higher education institution. In a Joint Degree programme, the curriculum shall

be designed jointly by the collaborating Indian & Foreign Higher Educational Institutions and the Degree is awarded by the Indian Higher Education institution and the collaborating foreign higher education institution with a single Certificate. And in the Dual Degree Programme, degrees shall be conferred by the Indian and foreign higher education institutions, separately and simultaneously, upon completion of degree requirements of both the institutions. Such regulations could be earmarked for linking two institutes within India.

The vacancy of teaching post and the delay in recruitment process is another challenge in making state an education hub. One respondent quoted that Bihar public service commission has published vacancy in 2014 to recruit faculty in engineering colleges and gave joining in 2018. Such long delays in faculty recruitment should be avoided. Faculties are quintessential element of technical education. They provide support system to education. So, proper faculty-student ratio should be maintained through timely faculty recruitment drive. So, if quality of engineering education is maintained, then the affordable engineering education in Bihar could be promoted as an advantage to attract students from outside state and from foreign nation.

> In general, more than half of students in German university are foreigner due to low cost of education along with quality. India is a destination in world for health tourism due to affordability and quality. This could also be replicated for developing Bihar as hub for engineering education.
>
> Head of the Department, Male, Public Engineering Institute, Patna

All the teaching and non teaching staffs needed to be bold enough to initiate new and innovative practices in engineering colleges of the region. And the faculties taking such initiatives should be motivated and honored. The colleges in the state should be renovated with modern education system and infrastructure. The affordability of engineering education in the state could become an attraction for ASEAN countries in particular and for the world in general. Since, the per capita income in Nepal is low, so such students might need subsidy from government of Nepal. The coming of foreign students in Bihar

engineering colleges would in turn improve the exposure of local students and aid in quality technical education.

****
****

Chapter-3: Factors Influencing Location of Institutes

As per AICTE (2021), Bihar has 57 engineering and technology institutes while Tamilnadu has 495 of such institutes. So, why some states have large number of colleges, while other states have very few? This chapter examines the factors which affect the number of higher technical institutions in a region or state. Then to quantify this relationship between location and factors, it performed regression analysis of the *Locational variable* with these *factors*. The factors which decide the establishment of engineering/technical institutes in a region are diverse. But, these could not be defined into fixed or definite number, deciding the location of an engineering institute. So, there are various socio-political-cultural-economic and administrative factors.

3.1 Analysis of factors

So, for study purpose and based on analysis of primary and secondary data, this research paper has identified following broad factors, influencing the location of higher technical institutions in a region. To find such factors, primary data was used. Response on Likert scale was collected, where 90 respondents have given their feedback. Their responses were analyzed with help of SPSS. After analysis, these variables were grouped broadly into following five factors namely administrative factors, demographic factors, economic factors, educational resource factors and physical factors.

a) Administrative factors

Government expenditure on technical education and its policy towards technical education is one of the most important factors deciding location. Almost half of the respondents have agreed that government expenditure is a major factor deciding location of engineering institute. But, with regard to government policy as a factor, 80 percent of the respondents have agreed on it.

Table 3.1: Response on administrative factors affecting location (N=90, Data in %)

Factors	S. Disagree	Disagree	Neutral	Agree	S. Agree
Gov. Expenditure	4.4	12.2	35.6	37.8	10
Government Policy	0	5.6	14.4	56.7	23.3
Law and order	1.1	6.7	16.7	47.8	27.8
Social Infrastructure	2.2	10	17.8	38.9	31.1

Source: Primary data

Then, the state government administrative machinery, the state law and order situation and the availability of social infrastructure like electricity, connectivity etc. are among major factors which affects the location of the technical institutes. More than three-fourth of the respondents agreed that government administrative machinery and law and order situation in the state or region is a dominating factor to decide location. Similarly 70 percent of them have voted for social infrastructure as a factor for location.

b) Demographic Factors

Population in the age group 18-23 of the state, social demand (number of registrants for engineering entrance exam), the admission rate/enrollments in technical institutes, the ideological preference for technical education among parents and students are some of the demographic factors affecting the location of technical institutes in a region or state. One third of the respondents have considered 18-23 cohort of population as a factor for location. But more than half of the respondents have agreed on social demand as a factor which decides location of technical institutes in a region.

Table 3.2: Response on demographic factors affecting location (N=90, Data in %)

Factors	S. Disagree	Disagree	Neutral	Agree	S. Agree
18-23 age population	6.7	22.2	27.8	30	13.3
Social Demand	6.7	16.7	20	42.2	14.4
Enrollment	5.6	21.1	20	43.3	10
Ideological preference	6.7	14.4	15.6	47.8	15.6

Source: Primary data

At the same time, the enrollment or admission rate in the existing engineering colleges in a region is considered as factor for opening new technical institute by 53 percent of the respondents. The large number of vacant seats at engineering colleges discourage establishment of new such colleges. The ideology behind engineering education and being an engineer is an influencing factor for establishing technical institutes. 63 percent of respondents considered ideological preferences as a factor.

Taking data from Table 2.1 under Chapter 2, the correlation was established among the three variables namely *number of engineering colleges in each state, population in 18-23 cohorts* and *enrollment in such institutes in those states*. The correlation coefficient between number of college and population comes out to be 0.589 which was significant

at 0.01 level. So, it showed moderate correlation among these two variables. Similarly, the correlation coefficient between number of college and total enrollment in engineering colleges comes out to be 0.964 which was significant at 0.01 level. Thus there was high correlation between number of engineering institutes and enrollment in such colleges for each state.

Then, relation between social demand and number of colleges could also be understood from the following data. It was found that, a total number of 6.52 lakh candidates were registered for the JEE (Main) Examination for B.E./B.Tech examination held in February 2021(National Testing Agency, 2021). Maharashtra, Andhra Pradesh, Telangana and Utter Pradesh were the top four states having the highest number of registrations for JEE (Main) 2021. And table 2.1 showed that top 7 states having the highest number of engineering colleges are Tamilnadu, Maharashtra, Andhra Pradesh, Utter Pradesh, Telangana, Karnataka and Madhya-Pradesh. Thus, here also strong similarity existed between social demand and existing number of engineering colleges.

c) Economic Factors

The per capita income in a state, the level of employment among technical graduates, the presence of knowledge based industries in a state, the degree of urbanization in a state are some of the economic factors which affect location of technical institute. Economic capacity of people also motivates the establishment of engineering colleges in a region. Government's concession in opening a college is another factor.

From the analysis of primary data, it was found that half of the respondents have considered per capita income as factor for location. 70 percent of the respondents have agreed on employability as an important factor for location. And same percentage of people have voted that knowledge based industries in the region is an important considerate while establishing a technical institution in the region. And 65 percent of them have considered urbanization of the state as a factor.

Table 3.3: Response on economic factors affecting location (N=90, Data in %)

Factors	S. Disagree	Disagree	Neutral	Agree	S. Agree
Per capita income	4.4	18.9	21.1	40	15.6
Employability	6.7	7.8	15.6	36.7	33.3

Knowledge based Industries	7.8	11.1	11.1	40	30
Urbanization	4.4	10	21.1	45.6	18.9

Source: Primary data

From the analysis of secondary data based on Table under annexure-3, the correlation among *number of engineering colleges* in each state with *urbanization rate, number of factories, Net state domestic product (NSDP) and Per-capita NSDP* was established. The correlation coefficient comes out to be 0.066, 0.896, 0.844 and -0.019 respectively. Thus, it showed very high correlation among *number of colleges, NSDP, and number of factories* in each state. At the same time, correlation with *urbanization* of each state was very low and with *per capita NSDP* comes out to be negative.

Most states, where large number of private institutes is there, provide subsidy to students belonging to own state. And to compensate, fee is higher for outsiders. Political benefit from private engineering college is taken directly or indirectly. These colleges are often taken as large income generating source and less interest is shown on improving quality.

d) Educational Resource Factors

The existing number of technical institutes in the region, the availability of qualified faculties, and the literacy rate in the state are important factor affecting location. The existing number of engineering colleges in a region is considered as factor for opening new technical institute by half of the respondents. Existing institutes in the region acted as both pull and push factor for creation of new institutions. If connectivity is better in the region, it attracts students and employers both and hence acted as pull factor for establishment of new educational infrastructure in the region. But, if enrolment in such colleges is low or seats going vacant, then it may also become push factor.

Table 3.4: Response on educational resource factors affecting location (N=90, Data in %)

Factors	S. Disagree	Disagree	Neutral	Agree	S. Agree
Existing institutes	4.4	13.3	32.2	36.7	13.3
Availability of Faculty	6.7	5.6	17.8	26.7	43.3
Literacy	4.4	7.8	30	33.3	24.4

Source: Primary data

On the other hand, 70 percent of them have believed that availability of qualified faculty in the state or region is an important factor deciding location. And more than half of them have considered literacy in the region as the factor for establishment of higher technical institutions. Qualified faculty also demand higher payment, but private colleges find it challenging to provide good pay scale to such faculties.

e) Physical Factors

The availability of land and the geography of a region are two influencing factor for location of technical institution. The type of terrain weather hilly terrain or plain area affects the connectivity and infrastructure creation. Private institutes often see the connectivity of a place before establishing an institute in a region. Weather they need to build a road there or road already existed, impacts the decision regarding establishment of new institutions.

Table 3.5: Response on physical factors affecting location (N=90, Data in %)

Factors	S. Disagree	Disagree	Neutral	Agree	S. Agree
Land	12.2	21.1	15.6	28.9	22.2
Terrain	16.7	18.9	24.4	24.4	15.6

Source: Primary data

More than half of the respondents have considered land as important factor affecting the location of technical institute. Densely populated states like Bihar and hilly states have large scarcity of land. In fact, with increasing population, availability of land in continuity, for creation of educational infrastructure is reducing day by day. It was also reflected through above table which showed that two-fifth of the respondents has agreed on geographical terrain as a factor.

3.2 Quantifying the relation of *Location* with *Factors*

Regression technique helps in assessing the strength of relationship among dependent and independent variables. It predicts the variance accounted by each predictor to the response. Now, depending on number of variable in the analysis, it could be bivariate (two variable) or multiple (Three or more variables) regression. Multiple linear regression models could be used to analyze Likert scale data only if data has normal distribution. If it fails normal distribution, then we need to use non-parametric test statistics.

This research paper has predicted the strength of relationship as follows:

$$Location\_HTE = \beta_o + \beta_1 * Adm\_Factor + \beta_2 * Dem\_Fac + \beta_3 * Eco\_Fac + \beta_4 * Edu\_Fac + \beta_5 * Phy\_Fac + e_i$$

Likert sale is an ordinal measurement, so ordinal logistic regression model could be used. The ordinal regression is done when dependent variable is in ordinal measurement scale and independent variable is in nominal or continuous measurement scale. But, if response is transformed to get dichotomous variable output, then binary logistic regression model could also be used.

Table 3.6: Three regression models

Multiple linear regression model	Binary logistic regression model	Ordinal logistic regression
$Y= b_o+b_1X_1+b_2X_2+\ldots..b_nX_n$	$logit(p)= b_o+b_1X_1+b_2X_2+\ldots..b_nXn$	$log(p/1-p)= b_o +b_1X_1+b_2X_2+\ldots..b_nXn$

Source: Hilbe (2016) & Bingham (2010)

Where b_o is constant, X is independent variable and Y is dependent variable, p is the probability of the occurrence of an event

Here Location_HTE is the dependent variable. β_o is the regression constant or intercept which represent a value of outcome if all the predictors are excluded. The β_1, β_2, β_3, β_4 and β_5 are regression coefficients representing slope. It shows, how strongly each independent variable predicts the outcome. And e_i is the error term which accounts for all other factors which cause variance in the dependent variable.

Table 3.7: Transforming the variable in SPSS

Variable No.	Transformed Variable Name	*Computing Method
1.	Location_HTE	MEAN(Suff_TI,Suff_Intk_UG,Suff_Intk_PG,Suff_Intk_doctrt,Relvnt_Discpln,Ratnly_distrbtd_TI)
2.	Adm_Factor	MEAN(F_Gov_Exp, F_Gov_Polcy, F_Admns_Law, F_Socl_Infr)
3.	Dem_Fac	MEAN(F_Popltn_Targt_age,F_Socl_Demnd,F_enrlmt,F_Ideolgcl_Prefrc)
4.	Eco_Fac	MEAN(F_PCI, F_Emplyt, F_KBI, F_Urbnstn)
5.	Edu_Fac	MEAN(F_currnt_No_TI, F_Faclty_Avlty, F_Litracy)
6.	Phy_Fac	MEAN(F_Land, F_Geog)

Source: Primary data

**Mean of Individual variables is taken. The individual variables represent the responses of Likert scale data*

Now, we need to test whether the transform variable has normal distribution. The following numerical and visual outputs should be examined for normality test. First, the skewness and kurtosis z values should be in the range of -1.96 to +1.96 at 95 percent confidence level (Cramer, 2003). Then, the Shapiro-wilk test p value should be above 0.05 (Razali & Wah, 2011). And the histograms, Normal Q-Q plots and Box plots should visually indicate the normal distribution of the data. The histograms should be close to normal curve. Then the data in the Normal Q-Q plots should be along the line as far as possible. And, the box plots should be approximately symmetrical.

The Box plot shows the center and spread of the data set. It helps in determining the skewness and the outliers. It could be understood graphically in five parts namely the top 25 percent, upper quartile, median, lower quartile and bottom 25 %. Thus the middle 50% shows the inter-quartile range. And the Whiskers (Ends) show the maximum and minimum value. The whiskers give the trend to identify outliers. Here the outliers are shown by symbol of circle (o) and extreme outliers are shown by asterisk (*). Outliers are at least 1.5 box lengths from the median and extreme outliers are at least 3 box lengths from the median.

Table 3.8: Test of Normality through Skewness and Kurtosis

Variables	Skewness	Std.Error	#Z-Value	Kurtosis	Std.Error	#Z-Value
Location_HTE	-.263	.254	-1.04	-.494	.503	-0.98
Adm_Factor	-.293	.254	-1.15	-.093	.503	-0.184
Dem_Fac	-.366	.254	-1.44	.139	.503	0.27
Eco_Fac	-1.048	.254	-4.12	1.322	.503	2.62
Edu_Fac	-.491	.254	-1.93	.052	.503	0.103
Phy_Fac	-.227	.254	-0.89	-1.031	.503	-2.05

Source: Primary data

 # Z value= [Measure of (skewness or Kurtosis)]/ Std. Error

Here, the z value for skewness for *Eco_Fac* does not lie in the normal range. Similarly, the z value for kurtosis for *Eco_Fac and Phy_Fac* do not lies in the normal range. And the box plot shows that there is no extreme outlier in the data set. And, there is only two outlier data in one of the variable named *Eco_Fac*. So, it was ignored.

Table 3.9: Test of Normality through Kolmogorov-Smirnov and Shapiro-Wilk test on mean transformed variable

Variable	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Location_HTE	.123	90	.002	.961	90	.009
Adm_Factor	.133	90	.000	.971	90	.044
Dem_Fac	.135	90	.000	.977	90	.109
Eco_Fac	.151	90	.000	.918	90	.000
Edu_Fac	.129	90	.001	.952	90	.002
Phy_Fac	.138	90	.000	.932	90	.000

Source: Primary data

Lilliefors Significance Correction

Our data set has the total number of sample equals to 90. And, the test showed that p value for all the variables is not non-significant. As, the p value for all variables except for Dem_Fac was less than 0.05 and hence significant. So, our data set for all the variables did not originate from a population with a normal distribution.

So, log transformation of variable was done. But, this log transformed variable also failed the normality test as evident from the table below. The significance level is below 0.05. So, we need to run non-parametric test. Now since the dependent variable here is Likert scale data, so ordinal logistic regression was performed.

Table 3.10: Test of Normality through Kolmogorov-Smirnov and Shapiro-Wilk test on log transformed variable

Transformed Variable Name	**Computing Method**	**Kolmogorov-Smirnov[a]**			**Shapiro-Wilk**		
		Statistic	df	Sig.	Stat.	df	Sig.
Log_Location_HTE	LG10(Location_HTE)	.184	90	.000	.902	90	.000
Log_Adm_Fac	LG10(Adm_Factor)	.170	90	.000	.941	90	.001
Log_Dem_Fac	LG10(Dem_Fac)	.172	90	.000	.902	90	.000
Log_Eco_Fac	LG10(Eco_Fac)	.196	90	.000	.768	90	.000
Log_Edu_Fac	LG10(Edu_Fac)	.165	90	.000	.886	90	.000
Log_Phy_Fac	LG10(Phy_Fac)	.186	90	.000	.874	90	.000

Source: Primary data
[a]Lilliefors Significance Correction

So, running ordinal regression in SPSS, the independent variables which were categorical are taken as factors and those treated as continuous are taken as covariate. So, here all the independent variables were taken as covariates. Also all the five independent variables were considered for scale model. And since, the data was on Likert scale for which ordinal regression was to be performed, so before analysis, the all variables data is converted back in Likert scale by rounding off.

Test of parallel lines

The null hypothesis says that the location parameters (slope coefficients) are the same across response categories. The location parameters were the five factors here (the predictors). And response categories were Location variable (the dependent variable). It represented the distribution of predictors towards outcome as uniform. The significance value should be more than 0.05 here.

Table 3.11: Information about Model-Fit, Goodness of Fit and Test of Parallel Lines

	Model	**-2 Log Likelihood**	**Chi-Square**	**df**	**Sig.**
Test of Parallel Lines[a]	Null Hypothesis	499.782			
	General	388.412[b]	111.37[c]	90	.063
Model Fitting Information	Intercept Only	503.086			
	Final	490.430	12.65	10	.244
Goodness-of-Fit	Pearson		1773.47	1643	.013
	Deviance		487.65	1643	1.000

Source: Primary data
a. Link function: Logit.

Model fitting information

If the significance value is less than 0.05, we reject the null hypothesis. The null hypothesis here tells that there is no significant difference between the baseline model (intercept only model) and the final model when we bring the predictors. Then intercept only is information about the model without bringing the predictors. That is, baseline model excluded all the independent variable and final model included all the independent variables. Since p value was greater than 0.05, so null hypothesis was accepted here. So our model is not significant (P value should be lower than 0.05 here).

Then, Goodness of fit helps in determining whether a model exhibit good fit to data. Null hypothesis here was that the observed data is having goodness of fit with the fitted model. Non significant value indicates that model fits the data well. Significant result (P value < 0.05) indicates that model does not fit the data well. (P value should be greater than 0.05 here).

Since, the model was not found to be fit during ordinal regression, so binary logistic regression was tried. For this purpose, the dependent variable was transformed to dichotomous variable. It was done using transform function (Recode into different variable) where Likert scale response 1 and 2 were transformed as '0' and response 4 and 5 were transformed as '1'. The response 3 under Likert scale who was undecided was left. Thus, this new transformed dichotomous dependent variable was named *T_Loc*. Independent variables could be categorical, ordinal or even scaled data.

The Hosmer & Lemeshow Test is a test of model fit. Here the significance value comes out to be 0.239 which is greater than 0.05. So, it showed model adequately fits the data. And Nagelkerke's R square is pseudo R square and is normally used rather than Cox and Snell R square. Nagelkerke's R square is adjusted representation of the Cox and Snell R square which adjust the scale to include complete range between 0 and 1.

Table 3.12: Information on model fit and R square

	Chi-square	**df**	**Sig.**	**Cox & Snell R Square**	**Nagelkerke R Square**
Hosmer & Lemeshow Test	9.198	7	.239		
Model Summary				.231	.369

Source: Primary data

The parameter estimates tells about how much each independent variable contributes to dependent variable. And, the p value for each variable tells if that contribution is significant or not. If the significance value is less than 0.05, then there will be a significant difference between the factors (independent variables) and the location (dependent variable) and null hypothesis could be rejected. The p value also tells if the relationship among sample also exists in large population. A low p value (less than 0.05) indicates that changes in the predictor's value are related to changes in the response variable.

Table 3.13: Parameter estimates for different factors as variables

	Estimate	**Std. Error**	**Significance**
Constant	-1.287	5.636	.819
Adm_Factor	.304	1.111	.785
Dem_Fac	-.273	.827	.742
Eco_Fac	.897	1.055	.395
Edu_Fac	-2.577	2.175	.236
Phy_Fac	1.534	1.056	.146

Source: Primary data

Thus, after performing regression analysis, the following relationship was established among location and factors:

$$Location\_HTE = \beta_o + \beta_1 * Adm\_Factor + \beta_2 * Dem\_Fac + \beta_3 * Eco\_Fac + \beta_4 * Edu\_Fac + \beta_5 * Phy\_Fac + e_i$$

Where, byta coefficient values are shown in the above table.

The table 3.13 represented the p values and the coefficients of regression. The coefficients described the mathematical relationship among location (dependent variable) and factors (independent variables).

Thus, the regression analysis gave both positive and negative values of regression coefficients for different five Locational factors. The regression analysis of primary data collected in the short span of time found to be not normally distributed and the estimate table showed non-significant values of greater than 0.05 for all the variables which affect

the location of an institute in a region, namely administrative factors, demographic factors, economic factors, educational resource factors and physical factors.

****

Chapter 4: Projection and Mapping

This chapter has projected the future demand of seats under engineering education and hence suggested the number of new engineering colleges required in the region. The new education policy 2020 targeted to achieve GER of 50 percent for higher education by 2035 from 27% presently (Government of India 2020). Then, this chapter has also mapped the engineering institutes of Bihar across regions. The spatial distribution of engineering colleges is important since it is the single most powerful geographical factor which impacts the access of engineering education. There is uneven geographic distribution of engineering colleges in India. This uneven distribution is more due to economic and political power distribution rather than social and demographic needs. This distribution was well understood with help of the mapping tool.

4.1 Projection of new institutes by 2035

First of all, let us examine why this projection was required? AISHE (2019-20) revealed that college density (the number of colleges per lakh eligible population i.e. in the age group 18-23) varied from 7 in Bihar to 59 in Karnataka as compared to All India average of 30. But, estimated Gross Enrolment Ratio (GER) in higher education in India was 27.1%, which was calculated for 18-23 years of age group. This proportion for Bihar was mere 14.5%. Also, the number of engineering and technology college in Bihar (3rd most populous state) was 57 while it was 455 in Tamil Nadu (AICTE 2021).

The same report also noted that in the stream-wise distribution of under graduate enrolments, Arts courses have highest percentage of 32.68 while engineering and technology represent 12.62 percent. Now, the number of senior secondary students in Bihar was 1.67 million in the academic year 2019-20 (UDISE plus dashboard). So, demand side showed that 12.62 percent of 1.67 million would be around 2 lakh engineering seats may be required. Then as per AICTE (2021), there are 57 engineering institutes in Bihar with intake of 14567. So, supply side showed that around 15k seats under engineering education are available. As per this calculation, new colleges would be required.

"Nearly 50 percent of the population lives in India's low income states, hill states, and states of the north east with poverty rates close to 48 percent. In these states, 16.8 percent of those in higher education study engineering courses, against 28.4 percent in other states."

World Bank, Government of India, 2017

Although, the seats in many engineering colleges in India remained vacant, but it is largely due to lack of quality education, poor employability as well as financial burden or disproportionate return of education, rather than quantity issue. At the same time, very less number of engineering colleges in a rural and densely populated state like Bihar along with low enrolment in higher education pointed towards poor availability and accessibility of such education. Then, according to PLFS (2018-19), the proportion of person of age 15 years and above under general education in India, who was graduate, was 8.5 percent and post graduate and above was 2.6 percent. The corresponding figure for Bihar was only 5.3 percent and 0.7 percent respectively. This proportion of such person having degree in engineering education at all India average was estimated at mere 0.6 percent.

Further, under chapter-2 of this research paper, it was found that the engineering college density (number of college per lakh eligible population) for Bihar was very low (around one-fifth) in comparison to country average. The number of engineering college at undergraduate and post graduate level per lack eligible population is more than 5 in states like Andhra Pradesh, Kerala, Tamilnadu and Telangana. But this figure was less than 0.6 in states like Bihar, Jharkhand, Assam and Meghalaya. Tamilnadu seemed to have more availability, with the college density of 7.41, while Meghalaya have least availability with college density as merely 0.29.

Then with regard to number of new institutions required, there were different views found through literature reviews. UGC (2008) emphasized for establishing at least 5000 more colleges across the country based on the GER of the constituent States. Even, if the fast increment is noticed in enrolment for engineering education, but still the percentage enrolment in engineering education is not up-to its potential.

Tilak & Choudhury (2021) argued that the relative share of engineering and technology education under higher education fell sharply from nearly 16 percent in 2015-16 to below 11 percent in 2018-19. But given increasing evidence of technology, one can expect that this trend would reverse. Ghose (2020) inferred that the Gross Enrolment Ratio in higher education among 18-23 years age group in Bihar was about 15 percent against national level of 25 % in 2016-17. To attain national level, the State needed additional 313 general colleges (Arts, Science and Commerce) and 236 Engineering Colleges. Dahiya (2020) has drawn an interesting inference that adding even 500 colleges every year in a country where about 5 crores people are added annually is not good enough to improve equity and accessibility in higher education.

AICTE committee for short and medium term perspective plan for technical education had found that capacity utilization in undergraduate and post graduate level was around 50 percent in 2017-18. So, it had recommended for non-creation of any new capacity from 2020 onwards (AICTE 2018). But, it also suggested reviewing this statement after two year.

But, this policy seemed to have missed the regional distribution and needs of less developed states like Bihar. The number of engineering and technology institutions is not in proportion to population. For example, it was very poor in high density and largely rural states like Bihar. Then came, new education policy 2020 after which Indian government targeted to add 3.5 crore new seats in higher education (Government of India, 2020).

There seemed north-east and south-west divide in India in terms of accessibility and availability under engineering education. Due to lack of proper number of engineering college and then job opportunities, brain drain from Northern and Eastern states to Southern-Western states of India seemed to be common phenomena. It is detrimental for own state. Students are forced to move out of state in lack of colleges and this is not always affordable for everyone. Particularly disadvantaged group and girls face more problems in moving out of state for study purpose.

Thus, participation of students under higher technical education got impacted by less availability of quality technical institutions. It was better understood with the help of regression analysis performed under Section 2.2 of Chapter 2 of this research paper. The

regression coefficient of 2.93 for college density with respect to participation, with significant value less than 0.05 reflected that it has large impact on participation. The placement rate has regression coefficient of 0.012 and significance value more than 0.05.

So, it invited the need for projection and mapping of engineering education to ascertain the requirement of engineering infrastructure. Also, the requirement of quantity of future engineers in Indian economy at each level and in all the courses should be ascertained to determine the intake or future expansion in engineering education. This would help in better examination of accessibility and availability of engineering education in the country.

Now, for projection of number of institutions, the projected population was required. As per National Commission on Population (2020), the projected population in the age group 18-23 for Bihar in the year 2036 will be around 15 million. By considering the New Education Policy 2020 target of GER for higher education as 50 percent by 2035, the projected enrolment in higher education by 2036 would be around 7.5 million. From the table below, the data of last ten years showed on average, around 79 percent student's enrollment at UG level. This proportion for Bihar in 2019 was around 88 % (Calculated from Table 6 of AISHE 2019-20).

Table 4.1: GER in Higher education, UG and engineering proportion (data in %)

S.No.	AISHE Report	GER in Higher Education	Enrolment proportion for UG	Proportion of Engineering among UG
1.	2019-20	27.1	79.5	12.6
2.	2018-19	26.3	79.8	13.5
3.	2017-18	25.8	79.2	14.1
4.	2016-17	25.2	79.4	14.7
5.	2015-16	24.5	79.3	15.6
6.	2014-15	24.3	79.4	16
7.	2013-14	23	79	17.4
8.	2012-13	21.5	80	17.3
9.	2011-12	20.8	80	17
10.	2010-11	19.4	80	16

Source: AISHE Reports from year 2019-20 to 2010-11 from the website of Ministry of Education

It may be assumed that in next few decades, enrolment at PG level and doctorate level would increase and hence, the proportion of UG students may decrease. So, for

calculation of required number of engineering seats at UG level by 2036, the 79 percent (country average) enrolment and not the enrolment proportion figure for Bihar was considered. So, the projected enrolment at UG level by 2036 could be around 5.9 million in Bihar.

Now, the out-migration is a global phenomenon. As per Census data on migration (2011), around 1.18 lakh people migrated from Bihar to other states within India for education reason (Table D-3 for India). From the same table, the migrants in Bihar from the states in India beyond the state of enumeration (from other Indian states) for education reason were 5363. So, the net out-migration in Bihar for education purpose as per this census was around 1.13 lakh for all the age group. Then from the table D-5 of Census (2011) data, for migrants' distribution with respect to age, the migration within the age group 20-24 for education reason constitute 18.2 % of all the migration for education reasons. So, net out-migration for education reason in Bihar for target age group would be around 20K.

Then according to Census 2011, the population of Bihar in the age group 18-23 was 10.42 million. And, as per AISHE (2011-12), the GER for higher education in Bihar was 12.5 percent. So, the number of such students in absolute terms would be 1.3 million. Thus, the percentage net out-migrants for education reason in 2011, with respect to all students enrolled in higher education in Bihar, came out to be 1.54 percent. So, considering the same ratio of Census 2011, the out migration of students of Bihar in 2036 in the age group 18-23, would be around 1 lakh. Adjusting this out-migration of students for higher education in Bihar, the projected enrolment at UG level by 2036 came out to be around 5.8 million in Bihar.

Now, from the same Table 4.1, the average enrollment of last 10 years, in engineering and technology course among undergraduates was around 15 %. Here, it needed to be clarified that, the author believes it to be more futuristic to consider country level average ratio, rather than taking present ratio of Bihar for calculation of projected engineering seats by 2036. Thus, the projected number of engineering students in Bihar by 2036 would be 8.7 lakh. So, number of projected UG level students in engineering courses per year (4 year course) could be fairly assumed to be 2.2 lakh.

Then, as per AICTE (2021), there were 57 engineering institutes in Bihar with intake of 14567. So, the projected number of new seats required to be added in engineering course in Bihar by 2036 comes out to be around 2 lakh. Now, the best engineering college in India as per National Institutional Ranking Framework, 2021 was IIT-Madras. The intake at UG level (4 year program) of this college was 762 in 2019-20 (National Institutional Ranking Framework, 2021).

So, even if, intake of each engineering college in Bihar by 2036 is assumed to be around 1000 for calculation proposes, then 220 engineering colleges would be required in the state by 2036. Reducing 57 exiting number of colleges, 163 new engineering colleges would be required by 2036 to achieve the overall target of 50 % GER in higher education. But, quality of education and infrastructure must not be compromised.

4.2 Mapping of Engineering institutes in Bihar

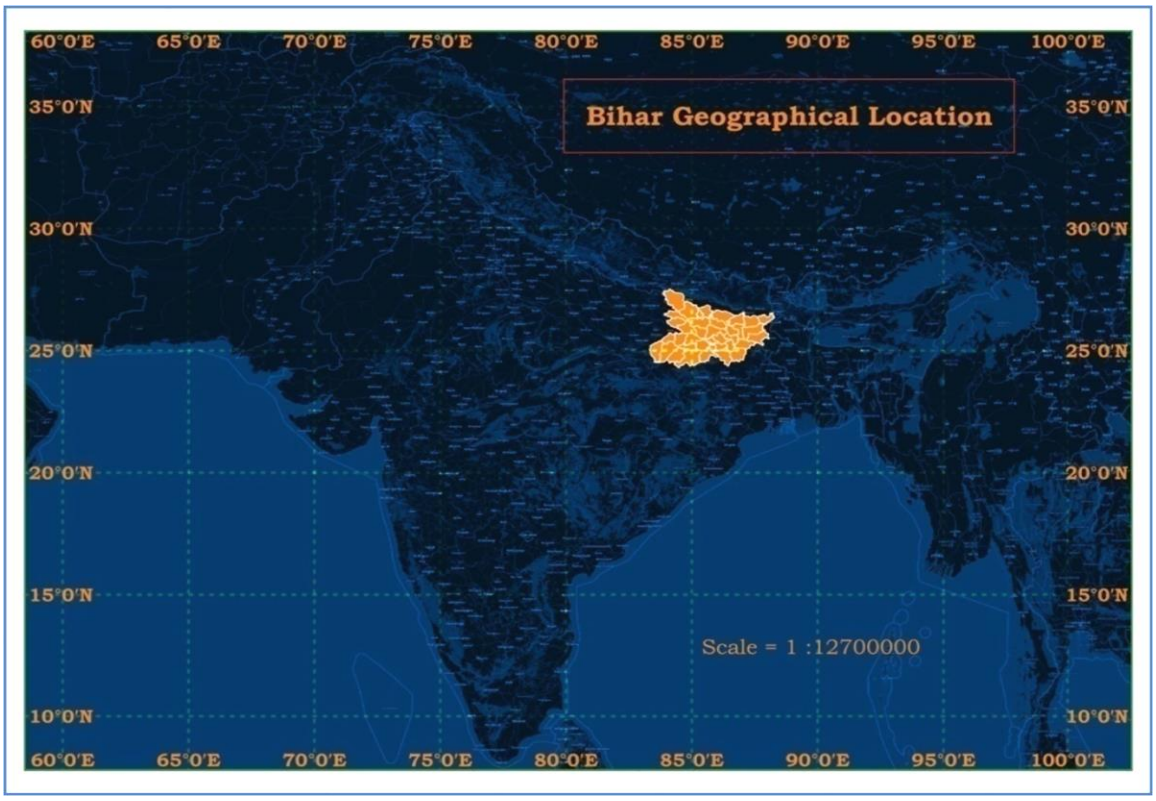
The phrase "geographic information system" was coined by Roger Tomlinson in 1963. According to NRSC (ISRO), Geographic Information System (GIS) is a technological tool used to describe and characterize spatially referenced information for the purpose of visualizing, querying and analysis. Using spatial analysis, GIS users can combine information from many independent sources and derive entirely new layers of information by applying sophisticated set of mathematical, statistical, imagery and graphical tools.

A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. By relating seemingly unrelated data, GIS can help individuals and organizations better understand spatial patterns and relationships. The two major types of GIS file formats are raster and vector. Raster formats are grids of cells or pixels. Raster formats are useful for storing GIS data that vary, such as elevation or satellite imagery. Vector formats are polygons that use points (called nodes) and lines. Vector formats are useful for storing GIS data with firm borders, such as school districts or streets (National Geographic website).

GIS data could include spatial as well as non spatial data. The location information like latitude, longitude, address, population, educational data and other detailed information could be included depending on the need. The data could be collected in various forms like cartographic data, photographic data, digital data, or data in spreadsheets. GIS allows integrating these informations on a single map. ArcGIS and QGIS are some of the GIS software used for this purpose.

The geographical location of an institute is an important factor influencing accessibility. The location of institutes within a particular district or state aids in accessibility of education, particularly for students belonging to disadvantaged and disabled groups, financially weaker section and girls' students. Thus the use of GIS tool would not only facilitate the examination of availability of engineering institutes and understanding the geographical spread, but would also suggest projected location of new HTIs.

Figure 4.1: Geographical Location of Bihar with respect to country



Source: Created by Author using QGIS

QGIS software was used for mapping and feeding the geographical information regarding engineering colleges in Bihar. The latitude and longitude information of various

engineering institutes in the region was obtained through Google search and by asking the college itself through RTI. Then this GIS data of each college was feed into excel sheet individually to add the latitude and longitude information into GIS map in the form of a point data. Here, this information is saved under CSV (comma delimited) file.

Then through the *add layer* and *add delimited text layer,* this excel data was imported under QGIS. Also, open street map was added using the *OSM Standard* feature of QGIS. Coordinate reference system used in this research paper for QGIS mapping was WGS 84 with encoding UTF-8. WGS (World Geodetic System) is a standard used in cartography. Its latest revision is WGS 1984 and maintained by National Geospatial Intelligence Agency, United States. Its origin is meant to be located at earth's centre of mass. It is based on world geodetic system 1984 ensemble (EPSG: 6326), which has a limited accuracy of at best 2 meters.

For visual representation on map, each engineering college in Bihar was assigned short acronym namely *college code* in the table below. The list of college and its district along with the college code were shown in the Table 4.2.

Table 4.2: List of Engineering Colleges in the state of Bihar

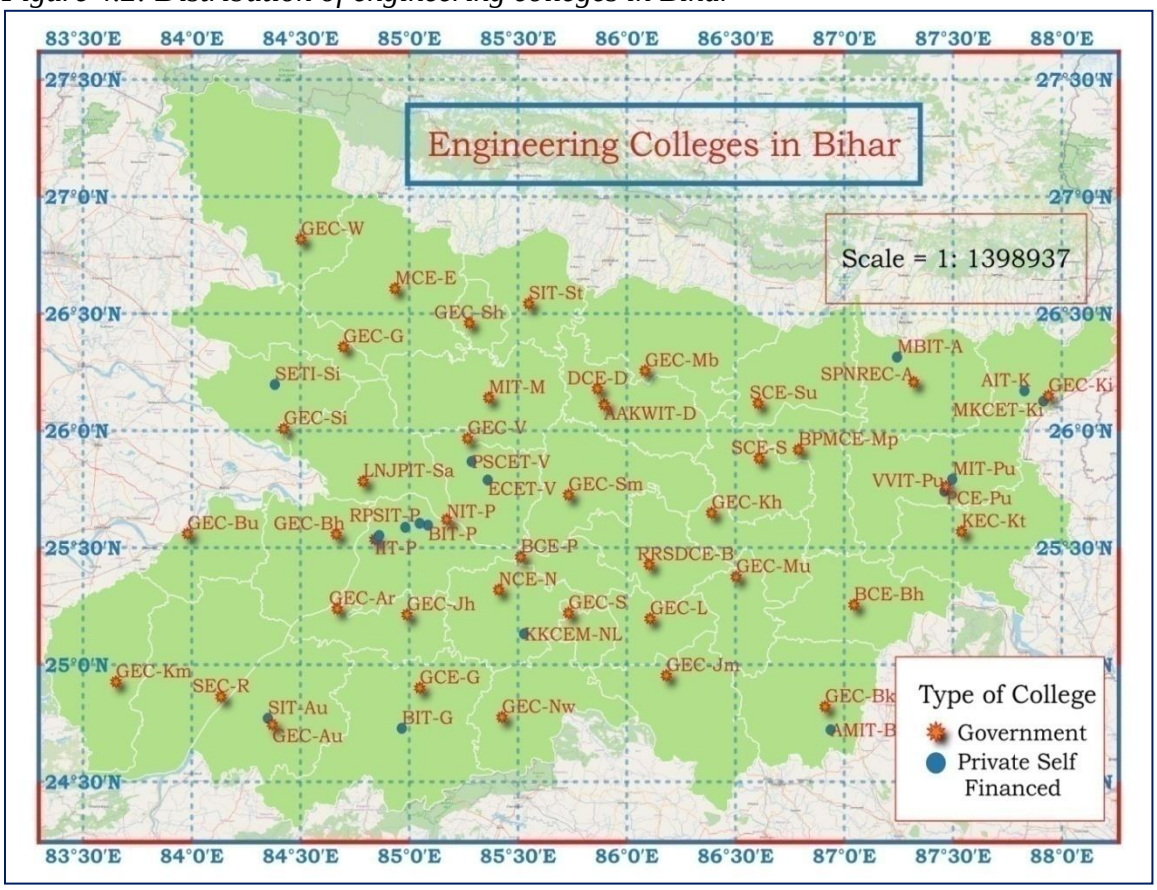
S.No.	Colg_code	Institute Name	District
1	LNJPIT-Sa	Loknayak Jai Prakash Institute Of Technology	Saran
2	SETI-Si	Siwan Engineering And Technical Institute	Siwan
3	GEC-Si	Government Engineering College	
4	GEC-G	Government Engineering College	Gopalganj
5	GEC-W	Government Engineering College	West Champaran
6	MCE-E	Motihari College Of Engineering	East Champaran
7	GEC-Sh	Government Engineering College	Sheohar
8	SIT-St	Sitamarhi Institute Of Technology	Sitamarhi
9	MIT-M	Muzaffarpur Institute Of Technology	Muzaffarpur
10	PSCET-V	Patna Sahib College Of Enginering & Technology(Pscet)	Vaishali
11	ECET-V	Exalt College Of Engineering & Technology	
12	GEC-V	Government Engineering College	
13	GEC-Sm	Government Engineering College	Samastipur
14	AAKWIT-D	Dr APJ Abdul Kalam Women's Institute Of Technology	Darbhanga
15	DCE-D	Darbhanga College Of Engineering	
16	GEC-Mb	Government Engineering College	Madhubani
17	SCE-S	Saharsa College Of Engineering	Saharsa
18	BPMCE-Mp	B. P. Mandal College Of Engineering	Madhepura
19	SCE-Su	Supaul College Of Engineering	Supaul
20	KEC-Kt	Katihar Engineering College	Katihar
21	MIT-Pu	Millia Institute Of Technology	Purnia
22	VVIT-Pu	Vidya Vihar Institute Of Technology	
23	PCE-Pu	Purnea College Of Engineering	

24	AIT-K	Azmet Institute Of Technology	Kishanganj
25	MKCET-Ki	Millia Kishanganj College Of Engineering & Technology	
26	GEC-Ki	Government Engineering College	
27	SPNREC-A	Shri Phanishwar Nath Renu Engineering College	Araria
28	MBIT-A	Moti Babu Institute Of Technology,Forbisganj	
29	AMIT-Bk	Adwaita Mission Institute Of Technology	Banka
30	GEC-Bk	Government Engineering College	
31	BCE-Bh	Bhagalpur College Of Engineering	Bhagalpur
32	GEC-S	Government Engineering College	Sheikhpura
33	GEC-L	Government Engineering College	Lakhisarai
34	GEC-Jm	Government Engineering College	Jamui
35	GEC-Mu	Government Engineering College	Munger
36	GEC-Kh	Government Engineering College	Khagaria
37	RRSDCE-B	Rashtrakavi Ramdhari Singh Dinkar College of Engineering	Begusarai
38	SIT-Au	Sityog Institute of Technology	Aurangabad
39	GEC-Au	Government Engineering College	
40	GCE-G	Gaya College of Engineering	Gaya
41	BIT-G	Buddha Institute of Technology	
42	GEC-Nw	Government Engineering College	Nawada
43	GEC-Ar	Government Engineering College	Arwal
44	GEC-Jh	Government Engineering College	Jehanabad
45	GEC-Km	Government Engineering College	Kaimur
46	SEC-R	Sershah Engineering College	Rohtas
47	GEC-Bu	Government Engineering College	Buxar
48	GEC-Bh	Government Engineering College	Bhojpur
49	MACET-P	Maulana Azad College Of Engineering And Technology	Patna
50	NIT-P	National Institute of Technology	
51	IIT-P	Indian Institute of Technology	
52	BIT-P	Birla Institute of Technology	
53	RPSIT-P	R.P.Sharma Institute of Technology	
54	NSIT-P	Netaji Subhas Institute of Technology,Bihta	
55	BCE-P	Bakhtiyarpur College of Engineering	
56	MIT-P	Mother's Institute of Technology,Bihta	
57	NCE-N	Nalanda College of Engineering, Chandi	Nalanda
58	KKCEM-NL	K.K. College of Engineering & Management	

Source: Primary data

Now, as discussed in this chapter, using CSV file, these colleges were mapped based on latitude and longitude information. There are few colleges which presently lacks its own building/physical infrastructure. Location for such colleges which were presently running at other campus in its own or different district, was taken as the location of its own city where college was proposed.

Figure 4.2: Distribution of engineering colleges in Bihar



Source: Created by Author using QGIS
Note: Longitude and latitude information taken from Google map.

The diagram showed that private colleges are very less in numbers in comparison to government colleges. The private colleges were concentrated in only few regions, mainly around Patna district. It also showed that almost every district has at least one HTI. So, although distribution of HTIs at country level was uneven, but the distribution in the state of Bihar largely seemed fair. The quality of such education available in each district with respect to buildings, labs, faculties and their qualifications apart from environment of engineering education was more of a concern in Bihar.

The capital city, Patna has highest number of HTIs (total 8) including NIT and IIT. Most of the institutions in the capital city have better infrastructure and quality of education, in comparison to other districts of the state. So, it attracted more number of students and hence capacity utilization was better in comparison to other districts in Bihar.

Figure 4.3: Engineering colleges in Patna district

Source: Created by Author using QGIS

Now, let us examine the population distribution in the state. In the table 4.3, the area and population (0-6 year) of each district of Bihar was collected from Census 2011 data. Then using MS Excel, percentage distribution of such population, district wise was found. Now, if we consider the same death and birth rate in 2030 as in 2011, and for time being, assuming migration is not significant in this age group, then it could be fairly assumed that more or less, the same population which was in the 0-6 cohorts in 2011 would move to 18-24 cohorts in 2029-30.

Table 4.3: Approximate distribution of population (18-24 year) across regions in Bihar in the year 2030

Division	District	#Area(Hect)	*Person	Percentage distribution	
Saran	Siwan	224410	532,868	2.9	9
	Saran	264887	657,316	3.5	
	Gopalganj	203774	437,031	2.4	
Tirhut	West Champaran	484351	753,429	4.1	21
	East Champaran	431715	993,569	5.3	
	Sheohar	43475	124,919	0.7	
	Sitamarhi	221891	643,851	3.5	
	Muzaffarpur	315351	817,709	4.4	
	Vaishali	201449	591,634	3.2	
Darbhanga	Samastipur	262390	784,203	4.2	12
	Darbhanga	254077	700,992	3.8	
	Madhubani	353498	779,360	4.2	
Kosi	Saharsa	164559	377,504	2.0	6
	Madhepura	179589	397,468	2.1	
	Supaul	238603	424,411	2.3	
Purnia	Katihar	291349	601,745	3.2	12
	Purnia	313883	644,083	3.5	
	Kishenganj	189080	341,943	1.8	

	Araria	271712	564,131	3.0	
Bhagalpur	Banka	305621	362,548	2.0	5
	Bhagalpur	254300	532,307	2.9	
Munger	Sheikhpura	62084	118,228	0.6	9
	Lakhisarai	128602	182,234	1.0	
	Jamui	305289	313455	1.7	
	Munger	139793	221,026	1.2	
	Khagaria	149342	347,048	1.9	
	Begusarai	187828	532,382	2.9	
Magadh	Aurangabad	330011	438,065	2.4	10
	Gaya	493774	762,507	4.1	
	Nawada	248732	367,231	2.0	
	Arwal	62631	123684	0.7	
	Jehanabad	94043	193946	1.0	
Patna	Kaimur	342447	291,785	1.6	16
	Rohtas	390722	493,047	2.7	
	Buxar	166999	286,969	1.5	
	Bhojpur	237339	440,847	2.4	
	Patna	317236	905,708	4.9	
	Nalanda	232732	501,046	2.7	
Bihar		9359568	9,359,568	100.0	

*Source: * 0-6 year district wise population of Bihar as per census 2011*
 # Area taken from website of Government of Bihar -Facts and Figures

In this research paper, for convenience and recommending distribution of engineering colleges in Bihar by 2035 (the target year when GER projected to be 50 percent), the state was divided into four zones based on population. This division was also done considering the north-south division of the state by river Ganga.

Table 4.4: Zonal division of Bihar based on projected population distribution by 2030

Zones	**Division included**	***Area**	**Population (18-24)**	**Present Distribution of Engineering Colleges**	
				Number	Percentage
Zone 1	Saran and Tirhut	2391303	30 %	12	21%
Zone 2	Darbhanga, Kosi and Purnia	2518740	30 %	16	28%
Zone 3	Bhagalpur and Munger	1532859	14 %	9	15%
Zone 4	Magadh and Patna	2916666	26 %	21	36%

Source: Primary data and Census (2011)
in Hectare: 1 Hectare = 10,000 Square meter= 0.01 Square kilometer*

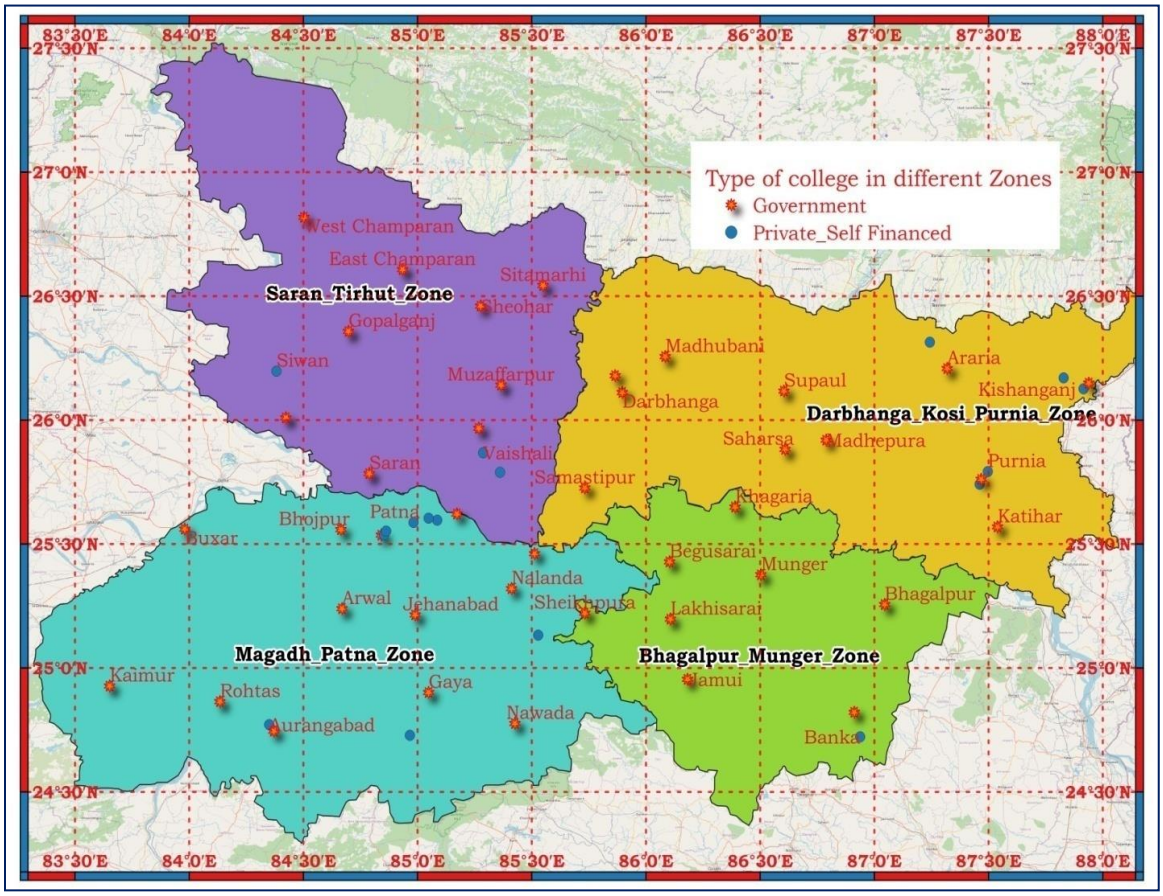
So, when it comes to even distribution of colleges, data showed otherwise. The population in 18-24 cohort would be highest under zone 1(Saran-Tirhut zone), but the number of colleges are highest in Zone 4 (Magadh and Patna Zone). Under zone 1 and zone 2, the population proportion would be 30 percent each, but college proportion is 21

percent and 28 percent respectively. Then zone 4 would have population proportion of 26 percent but college proportion is 36 percent.

Creating shape file by digitizing

Then geographical mapping of engineering colleges across the above four zones of Bihar was done using QGIS. Using *Create layer (New shape file layer*) with geometry type polygon, a shape file namely *Zone_Bihar* was created. Then by using *toggle editing* and *add polygon feature*, four new zones based on population was digitized.

Figure 4.4: Division of Bihar under various zones based on population



Source: Created by Author using QGIS

Now, this chapter calculated that 220 engineering colleges would be required in the state by 2036 including existing number of colleges. Their distribution among above four zones should be in proportion to population as shown in Table 4.5.

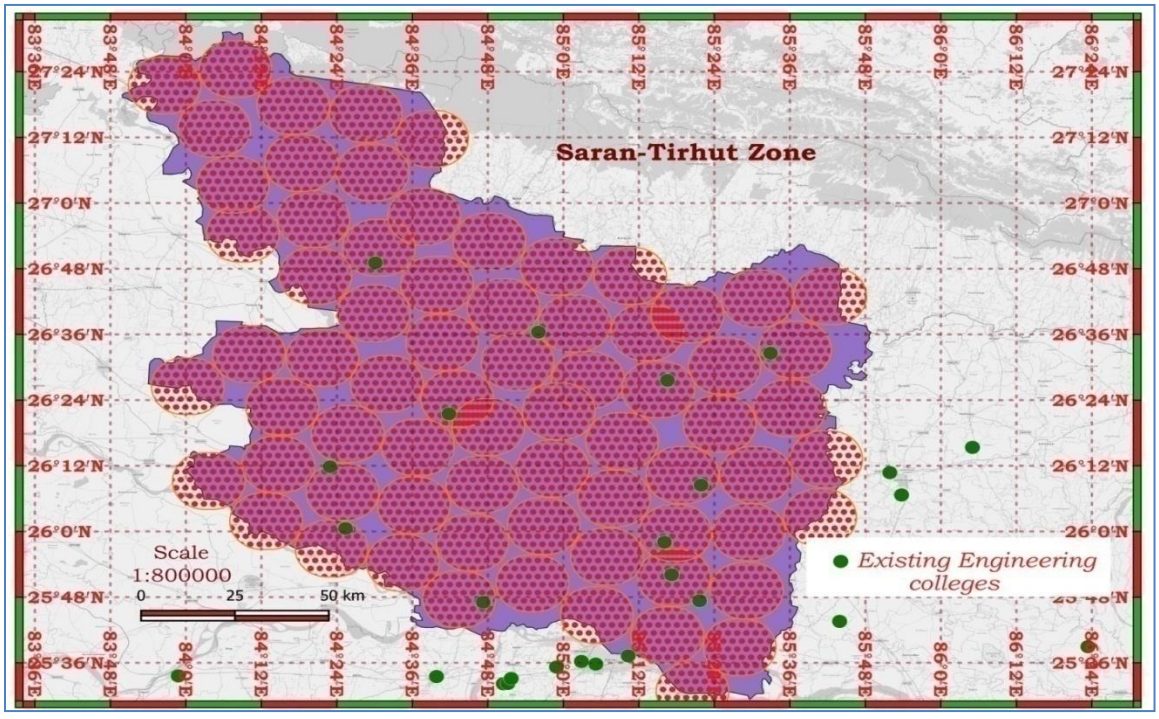
Table 4.5: Calculation of the radius of the circle for projected location of engineering colleges in Bihar

Zones	**Area(m^2)** (0000)	**Population (18-24)**	**Projected No. of Eng. colleges by 2036 (220)**	**Area per college(m^2)** (0000)	**Radius of the circle** (Km)
Zone 1	2391303	30 %	66	36232	10.7
Zone 2	2518740	30 %	66	38163	11.0
Zone 3	1532859	14 %	31	49447	12.5
Zone 4	2916666	26 %	57	51170	12.8

Source: Primary data and Census (2011)
Note: 1 Hectare = 10,000 Square meter= 0.01 Square kilometer

So, to carve the projected distribution and location, further mapping was done ahead. Each four zones were divided into circles by finding out proper radius. Under QGIS-Project properties, the units for distance measurements was taken as meters and units for area measurement was taken as square meters.

Figure 4.5: Projected location of new engineering colleges in Zone 1 (Saran-Tirhut zone)

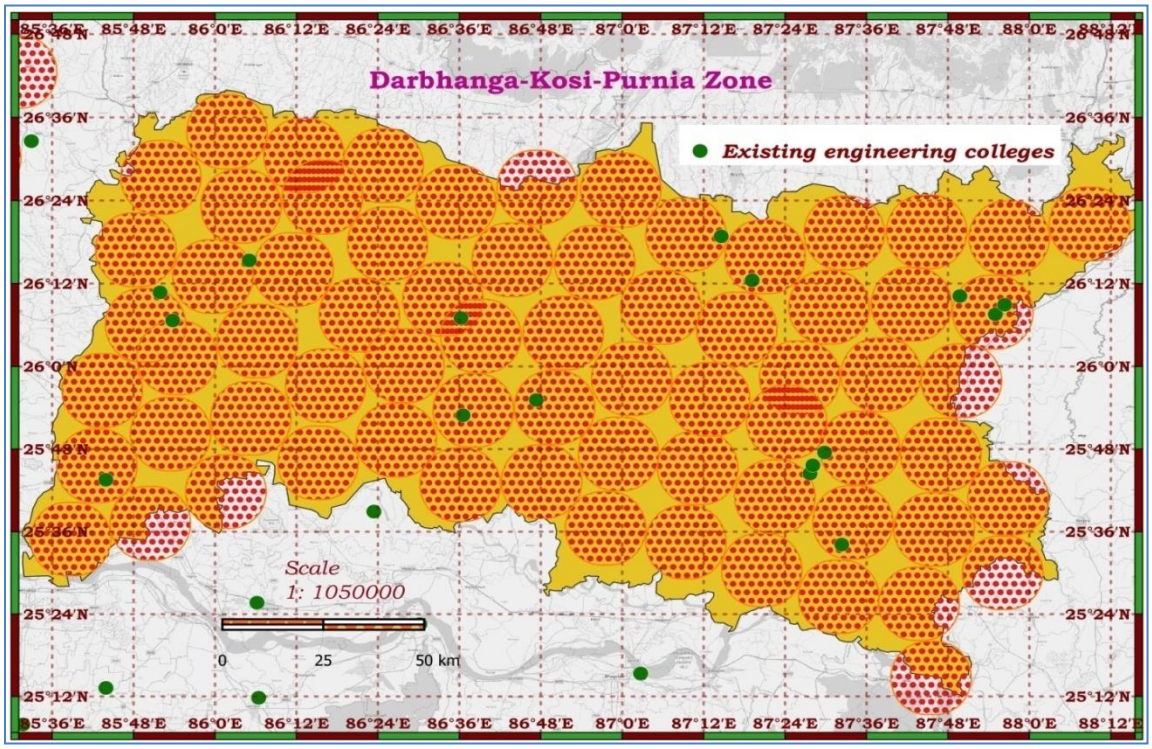


Source: Created by Author using QGIS

The new engineering colleges should be preferably located in these circular divisions. Green dots showed the existing colleges. The projected number of engineering colleges in zone 1 and zone 2, calculated in proportion to population came out to be 66 in each zone. The radius of the circle for zone-1 and zone-2 from the Table 4.5 came out to be around 11 km each and for zone-3 and zone-4, it was around 12.5 km each. Now, whole zone was divided in equal circular area.

While drawing the circle of calculated radius, the whole zonal area was tried to be covered and avoiding overlap as much as possible. But since the zonal regions naturally are not symmetric, so some overlap of circle could not be avoided and some buffer areas left. Never the less, it served the purpose. So, under QGIS mapping, d of the circle for zone-1 was taken as twice multiple of 10.7 km, equals to 21400 metre to avoid overcrowding. And, again under QGIS mapping, d of the circle for zone-2 was taken as twice multiple of 11 km, equals to 22000 metre to avoid overcrowding.

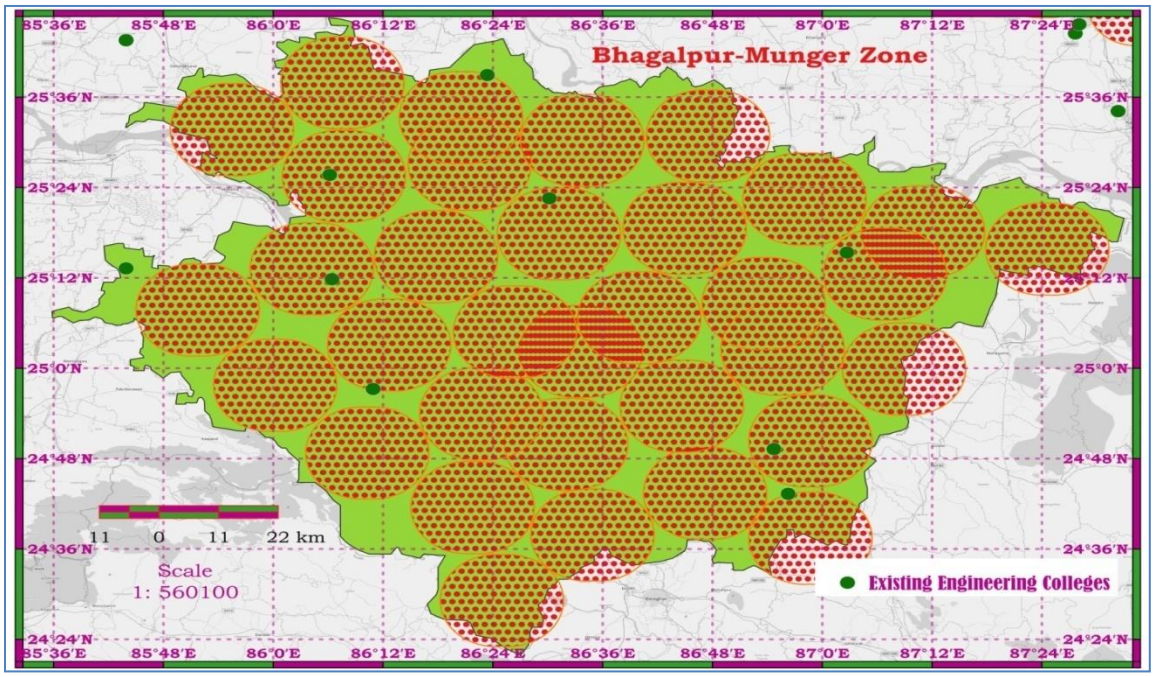
Figure 4.6: Projected location of new engineering colleges in Zone 2 (Darbhanga-Kosi-Purnia Zone)



Source: Created by Author using QGIS

Then, for zone 3 and zone 4, the number of projected engineering colleges with respect to population comes out to be 31 and 57 respectively. So, with respect to area of each zone, the radius of circle comes out to be around 12.5 km and 12.8 km respectively for each zone.

Figure 4.7: Projected location of new engineering colleges in Zone 3 (Bhagalpur-Munger Zone)

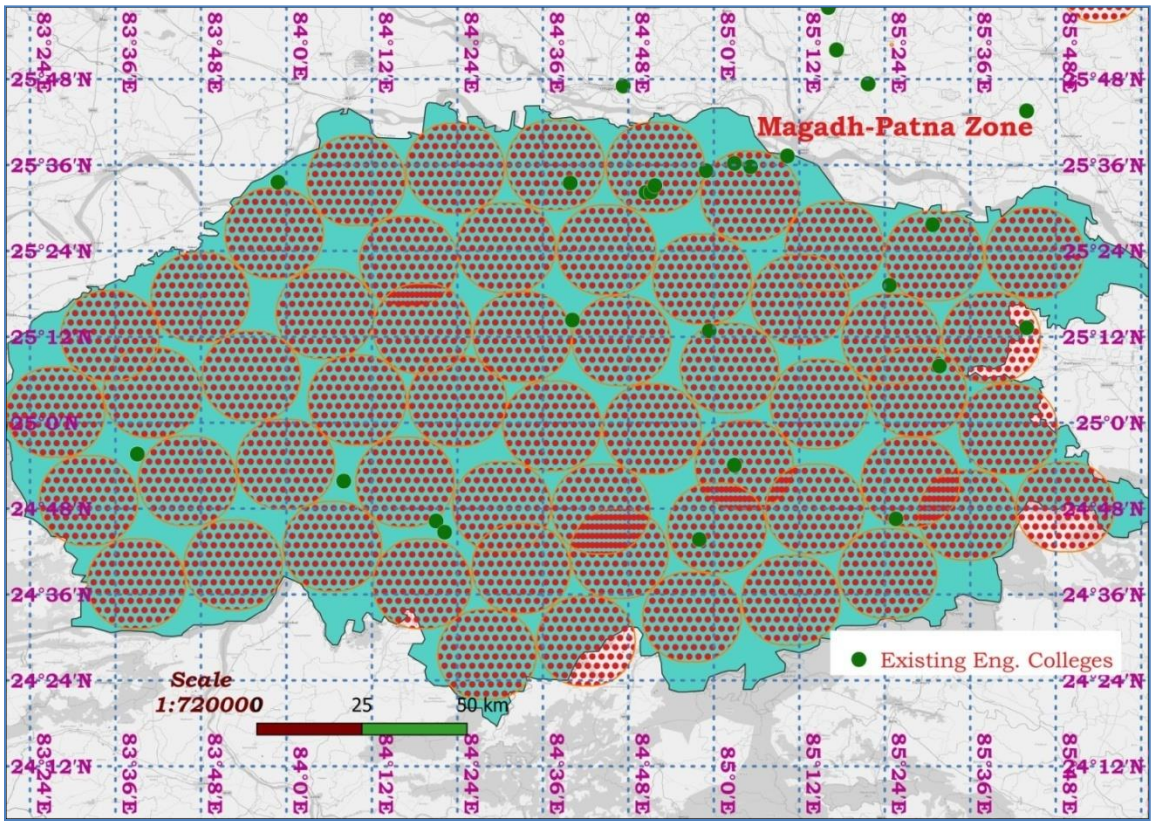


Source: Created by Author using QGIS

So, under QGIS mapping, d of the circle for zone-3 was taken as twice multiple of 12.5 km, equals to 25000 metre to avoid overcrowding. And d of the circle for zone-4 was taken as twice multiple of 12.8 km, equals to 25600 metre to avoid overcrowding.

Thus, each of the four zones were divided into circular areas as shown in figure 4.5, figure 4.6, figure 4.7 and figure 4.8. The circle diameter was different in each zone in proportion to the radius calculated for each zone. The scale used for each zone was also varied under QGIS, as per the suitability of the map. The scale was mentioned in each of the figures.

Figure 4.8: Projected location of new engineering colleges in Zone 4 (Magadh-Patna Zone)



Source: Created by Author using QGIS

Here, it needed to be clarified that each circle not necessarily represented the projected location of one college each. Rather, it was more as a suggestive location for new institutions and representation of the whole zones into circular division. It would help in creating even distribution of colleges in future based on population and area. New colleges could be established by choosing proportionate area under each of the zones. At the same time, location of college also depend on many other factors as discussed under chapter 3 of this research paper, like availability of land, political and economic constraints apart from socio-cultural reasons. So, the mapping done under this chapter was not part of deterministic approach, rather should be taken as an aid in decision making and of recommendatory nature based on future demand.

****

****

Conclusion

Equity, Sustainability, Productivity and Empowerment could be termed as quartets of human development. In this context, both accessibility and employability in engineering education become part of human development. The equal access to opportunities (education) would provide equity and then employability would enhance productivity. Further, Engineers have significant role in fulfilling the target of India to become $10 trillion economy by 2032. And, hence there comes the need for availability of quality technical education in a region. Then, the location and distribution of educational infrastructure is an important component of accessibility of education. In this context, the availability of higher technical institutions with quality education in a region becomes paramount for inclusive and equitable technical education.

Sustainable development goal, target-4 (SDG 4.4) aimed to substantially increase the number of youths and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship (UN 2015). So, this paper has examined the availability of higher technical institution through geographical mapping in a rural, largely backward and most densely populated state of India. At the same time, it also studied the participation of youth under higher technical education.

As per Census 2011, on the one hand, where Tamilnadu was the sixth largest populous state of India with 5.96 percent of national population and with a population density of 555, Bihar, on the other hand, was the third largest populous state with 8.6 percent of national population and with a population density of 1106. Even, for 2021, the projected population proportion with respect to whole country in the age group of 18-23 for Tamilnadu and Bihar was 4.6 and 10.1 percent respectively (calculated based on absolute data of projected population released by National commission on population, 2020).

But, when it comes to distribution of higher technical institutions in the country, then, where Tamilnadu has 495 engineering and technology institutes in the academic year 2021-22, Bihar has merely 57. This picture was further examined with the help of calculating the engineering college density for all the states of the country.

Table 2.1 calculated the engineering institute density for each state of India based on projected population in the age group 18-23 and AICTE data on number of institutes in the academic year 2019-20. The engineering college density varies from 7.41 for Tamilnadu to 0.29 for Meghalaya. This density for All India average was 2.23. Overall, the number of engineering college at undergraduate and post graduate level per lack eligible population was more than 5 in states like Andhra Pradesh, Kerala, Tamilnadu and Telangana. But this figure is less than 0.6 in states like Bihar, Jharkhand, Assam and Meghalaya.

The situation was even grave for Bihar. The eligible population in Bihar was 9.5 percent of eligible population of India. But number of engineering colleges was only 1.8 percent of corresponding number in whole country. In terms of total enrollment under engineering education as per AICTE, this figure came out to be 1.1 percent for the year 2019-20.

There is another issue of seats going vacant in many engineering colleges. The lagging quality of engineering education and non-proportional return of education are main reason for this situation. Then placements, lack of infrastructure in terms of laboratories, classrooms, equipments, lack of qualified faculties are few another reasons which cause the seats of engineering colleges going vacant.

At the same time, engineering education is an ever emerging field. So, the traditional disciplines are important, but must also inculcate the changing demand of industries by including new emerging disciplines as part of engineering education. The present trend in engineering education in Bihar was found not to be in sync with demand of the time.

Now, as far as participation of youths under higher technical education was concerned, it was limited by many constraints namely financial barriers, infrastructure barrier, gender barrier, employability and quality issues, college management issues and geographical barrier among many others. The poor pupil-teacher ratio, lack of infrastructure facilities etc. also decreased participation of students in technical education. The faculty student ratio among engineering institutes for the country with respect to intake in academic year 2019-20 was found to be 1: 14.3 while same for Bihar was 1: 18.2.

The government has taken some of the remarkable steps to reduce these barriers like incorporation of supernumerary seats, student credit card scheme, increase in education budget etc, but still long way to go. For example, the female participation among engineering colleges was mere 30 percent at national average while it varied from 14.9 percent in Bihar to 40 percent in Andhra Pradesh. But, their population in the 18-23 cohort was around half of total population of the country in the same year.

Similarly, proportion of scheduled castes and scheduled tribes was seen among total projected population of India of 2021 under 18-23 cohorts. The figures were found to be 16.78 percent and 8.4 percent respectively. But, the proportion of SC and ST students as part of all the students who registered for engineering entrance exam was merely 8.8 % and 3.4 % respectively in the year 2021. So, it pointed low participation of students belonging to disadvantaged group.

Further to understand the relationship of participation with the availability of the colleges, management type, intake and placement, regression was performed. First, the correlation coefficient of participation rate with college density and placement rate came out to be 0.932 and 0.539 respectively, which was also significant at 0.01 level. Also, the correlation of dependent variable (enrolment) with independent variable (management type) came out to be very low (0.196). Finally, the coefficient of regression among participation as dependent variable and college density and placement rate as independent variable came out to be 2.93 and 0.012 respectively with constant (intercept) value as -1.728.

Going further, quality of technical education is as important a concern as the quantity of such institutes. Pupil-teacher ratio, availability of infrastructures like classrooms, laboratories, cultural and sports spaces and facilities in colleges, inclusion of emerging engineering disciplines, regular update of syllabus as per changing needs of the industries, employability etc. are emerging quality issues under technical education. Employability is often an important manifestation of quality of education. Measuring employability is a tedious and complex task. The whole landscape of talent is changing in 21st century. So the employability of engineers got redefined as per new industrial needs. It was also witnessed through the low placement of engineering graduates.

The placement rate at all India level was found to be 51.3 percent for the academic year 2018-19. So, around half the passing engineering graduates were not employed as they pass from the college. The highest placement from engineering college was from Tamilnadu (70.8 %) which pointed more employability in the state for graduating engineers. The lowest employability for engineering graduates was found in Nagaland (14.9 %). The placement percent for graduating engineers in 2018-19 for Bihar was approximately half than national average. The states/UT like West Bengal, Utter Pradesh, Uttrakhand, Telangana, Tamilnadu, Odisha, Haryana, Delhi, Chandigarh and Andhra Pradesh has placement percent better than national average. But other remaining states performed worst in terms of employability of passing engineering graduates.

Then, Bihar has legacy of hosting ancient world famous Nalanda University. The state shares international border with Nepal and is in proximity to Bhutan, Bangladesh, Myanmar and other south East Asian nations. The affordability of education and living standard in Bihar could also become an advantage to attract foreign national students. So, the state has potential to become hub for engineering education even for foreign students, if quality technical education is provided.

Now, there comes the need for examining the reason of why some states have higher number of technical institutions in its region, while on the other hand, other states are deprived of such colleges, not only in terms of quantity but also quality. It was found that, although the factors which affect the location of colleges are varied, but for the sake of study, these could be more or less classified into five broad factors. These are Administrative factor, Demographic factors, Economic factors, Educational Resource factors and Physical factors.

Administrative factors mainly included government expenditure, government policy, law and order, social infrastructure etc. Then, demographic factors mainly included 18-23 age population, social demand, enrollment, ideological preference etc..The economic factors mainly included per capita income, employability, knowledge based industries and urbanization. At the same time, educational resource factors consisted here, the number of currently existing institutes, literacy rate in the region and availability of faculties. And finally, the physical factors included availability of land, geographical terrain etc.

The relationship of these five broad factors with the location of a technical institute was also quantified in this paper. Likert scale primary data was used for this purpose. The estimates after regression analysis came out to be -1.287, 0.304,-0.273, 0.897,-2.577and 1.534 for constant, Adm_Factor , Dem_Fac , Eco_Fac, Edu_Fac, Phy_Fac respectively.

Moving ahead, the location of an institute is one major factor affecting enrollment or participation. Location in terms of geographical terrain, metropolitan or urban area, connectivity etc. attracts or repels employers and students both. Also, New Education policy 2020 aimed to increase the Gross Enrolment Ratio in higher education including vocational education from 26.3% (2018) to 50% by 2035. In this context, government planned to add 3.5 Crore seats in higher education. So, the chapter 4 has projected the future demand of seats under engineering education and hence suggested the number of new engineering colleges required in Bihar. Then, it also mapped the engineering institutes of Bihar across regions. The spatial distribution of engineering colleges is important since it is the single most powerful geographical factor which impacts the access of engineering education.

The projected number of new seats required to be added in engineering course in Bihar by 2036 comes out to be around 2 lakh. Now, if intake of each engineering college in Bihar by 2036 is assumed to be around 1000 for calculation proposes, then, 163 new engineering colleges would be required by 2035-36 in sync with the India's target of achieving 50 % GER in higher education. But, quality of education and infrastructure must not be compromised.

There seemed north-east and south-west divide in India in terms of accessibility and availability of engineering education. Due to lack of proper number of engineering college and then job opportunities ,brain drain from Northern and Eastern states to Southern-Western states of India is common phenomena which is detrimental for own state.

Then, QGIS software was used for mapping the engineering institutes in Bihar and examining the geographical spread. Further, for recommending the future location and distribution of engineering colleges in Bihar, the state was divided into four zones based on population. This division was also done considering the north-south division of the

state by river Ganga. Considering the projected population by 2035-36, the population in 18-24 cohort came to be highest in zone 1(Saran-Tirhut zone), but the number of colleges are highest in Zone 4(Magadh and Patna Zone). Under zone 1 and zone 2, the population proportion came to be 30 percent each, but college proportion is 21 percent and 28 percent respectively. Then zone 4 has population proportion of 26 percent but college proportion is 36 percent. Finally, all four zones were divided into equal circular area. The radius of the circle for zone-1 and zone-2 calculated by author came out to be around 11 km each and for zone-3 and zone-4, it was around 12.5 km each.

While drawing the circle of calculated radius, the whole zonal area was tried to be covered and avoiding overlap as much as possible. Since, the location and establishment of institutions in a region depends on many socio-economic-administrative factors including availability of land, so, mapping the projected location should not be considered as deterministic approach rather only recommendatory nature. Each circle not necessarily represented the projected location of one college each. Rather, it was more as a suggestive location for new institutions keeping all other factors in mind.

****

Recommendations

- Although seats under many engineering college in India going vacant, but this could not and should not be extrapolated to conclude that there is sufficient availability of HTIs in the country. The reasons for it were discussed in this paper.

- But, whatever the reason of seats going vacant, the non optimal utilization of capacity leads to administrative burden on institutions, which in turn impacted the quality of higher technical education. So, there is need for overcoming this vicious cycle. As the quality of engineering education would improve, the financial return of technical education for students would be enhanced and hence it would further attract student, thereby increasing participation and reducing vacancy of seats under engineering education.

- Tamilnadu seems to have more availability with the engineering college density of 7.41, while Meghalaya seems to have least availability with college density as merely 0.29. So the number of new engineering colleges should be decided considering college density as one of the factor. The GER for higher education and technical education in Bihar was much below than even national average. With the increasing role of technology under Industry 4.0 environment, more participation under technical education is expected and hence more institutions would be required in phased manner.

- New and emerging branches under technical education should be added like drone technology, agro-based technologies, bio-technology, nano-technology, environmental engineering, Artificial intelligence and Internet of Things, architecture engineering, space technology, marine engineering etc. These courses could even be added in modules under credit based system. The knowledge of other traditional and core engineering branches could be integrated.

- The projected number of new seats required to be added under engineering courses in Bihar by 2036 came out to be around 2 lakh. Now, if intake of each engineering college in Bihar by 2036 is assumed to be around 1000 for

calculation proposes, then, 163 new engineering colleges would be required by 2035-36, in sync with the India's target of achieving 50 % GER under higher education. But, quality of education and infrastructure must not be compromised.

- The projected demand of number of engineering colleges in Bihar by 2036 under zone-1, zone-2, zone-3 and zone-4 came out to be 66, 66, 31 and 57 respectively, based on projected eligible population.

- Since, the location and establishment of institutions in a region depends on many socio-economic-administrative factors including availability of land, so, mapping done in this paper for the projected location should not be considered as deterministic approach rather only recommendatory nature.

- Bihar has legacy of hosting ancient world famous Nalanda University. The state shares international border with Nepal. It is also in proximity with Bhutan, Bangladesh and Myanmar apart from east and south Asian countries. The lower fee for technical education in Bihar and affordable life style, in comparison to other states, could become an advantage, if education standards were maintained. So, the state has potential to become hub for engineering education even for foreign students, if quality technical education is provided.

- The faculty student ratio among engineering institutes for the country with respect to intake in academic year 2019-20 was found to be 1: 14.3 while same for Bihar was 1: 18.2. So, recruitment of faculties should be expedited.

- There is lack of optimal environment under most engineering colleges in Bihar. The lack of discipline among students was found to be a major concern. The campus life should be improved.

- More number of inter-college exchanges and industry exposure required in the technical institutions in the country in general and Bihar in particular.

- The establishment of new industries should be encouraged in Bihar to utilize the human resource being generated under engineering colleges. Start-ups should be promoted in the colleges itself.

- Very low fee charged for education under Bihar government engineering colleges seems to be non-sustainable for maintaining quality technical education. Rather, financial loans to students could be a better alternative.

****

References

Altbach, P. & Mathews, E. (2021).Too many IITs, Unrealistic Expectations. The Hindu 20 February 2021, New Delhi

Agrawal, S., & Gupta, R. D. (2016). school mapping and geospatial analysis of the schools in jasra development block of india, International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences, 41

AICTE.(2018).Engineering Education in India-short and medium term perspectives. AICTE Committee for preparing short and medium term perspective plan for technical education

AICTE (2021).All-India Council for Technical Education, accessed on 11th September 2021. https://facilities.aicte-india.org/dashboard/pages/dashboardaicte.php

AISHE.(2010-2019). Ministry of Education. Government of India. https://www.education.gov.in/en/statistics-new?shs_term_node_tid_depth=384

Bihar budget. (2021-22).Finance department, Government of Bihar. Posted on PRS India. https://prsindia.org/files/budget/budget_state/bihar/2021/State_Budget_Analysis_2021-22-Bihar.pdf

Bingham, N. H., & Fry, J. M. (2010). Regression: Linear models in statistics. Springer Science & Business Media.

Blom A. & Saeki, H. (2011).Employability and skill set of newly graduated engineers in India. World Bank Policy Research Working Paper, (5640)

Bordogna, J., Fromm, E., & Ernst, E. W. (1995). An integrative and holistic engineering education.,Journal of Science Education and Technology, 4(3), 191-198

Census.(2011). Government of India.https://censusindia.gov.in/2011-prov-results/paper2-vol2/data_files/Bihar/Chapter_II.pdf

Chatterjee, A. (2021).How to grow better college. The Indian Express 12 March 2021, New Delhi

Chithra, R. (2013).employability skills–a study on the perception of the engineering students and their prospective employers. Global Journal of Management and Business Studies, 3(5), 525-534.

Choudhury, P. K. (2016): Growth of engineering education in India: Status issues and challenges, Higher Education for the future, 3(1), 93-107.

Cramer, D. (2003). Fundamental statistics for social research: step-by-step calculations and computer techniques using SPSS for Windows. Routledge.

Dahiya, B. S. (2020).Accessibility, Excellence, and Accountability in the Indian Higher Education System. Studies in Humanities and Social Sciences, 9(2), 17-27

Diaz Lantada, A. (2020).Engineering education 5.0: Continuously evolving engineering Education, International Journal of Engineering Education, 36(6), 1814-1832.

Ghose D S. (2020). Challenges of Higher Education in Bihar, Research Gate

Government Engineering College. Nawada (2021). Fee structure and other details. https://www.gecnawada.org.in/2021/11/25/information-for-admission-2021-22/

Government of Bihar. (2016).Bihar student credit card Yojana https://www.7nishchay-yuvaupmission.bihar.gov.in/guidelines

Government of Bihar.(2021). Udyog Vibhag. Ethanol Production Promotion Policy, 2021.https://state.bihar.gov.in/industries/cache/26/24-Mar-21/SHOW_DOCS/circular-gov-757-dtd-17-03-21.pdf

Government of Bihar.(2022). Facts and Figures.District wise Classification of Area

https://state.bihar.gov.in/main/cache/1/Figures/Table-050.pdf
Government of Bihar.(2021). DD NEWS. Accessed on December 21, 2021 https://ddnews.gov.in/national/bihar-cm-announces-33-reservation-girl-students-engineering-medical-colleges
Government of India.(2020). Ministry of Education National Education Policy 2020 announced. Posted by PIB,July 29,2020 https://pib.gov.in/PressReleasePage.aspx?PRID=1642061
Government of India. (2021).Ministry of Finance, Economic Survey 2020-21, Statistical Appendix https://www.indiabudget.gov.in/economicsurvey/doc/Statistical-Appendix-in-English.pdf
Hilbe, J. M. (2016). Practical guide to logistic regression. crc Press.
Hindustan Times (2020).June16 Accessed on 29 July 2021 https://www.hindustantimes.com/india-news/govt-readies-3-pronged-plan-aimed-at-making-india-a-10-trillion-economy-by-2032/story-sIfaQjbcGKEsMXU4ZKQ5bK.html
Jaffrelot, C & Jumle, V (2019). "The Problem of Skilling India". The Indian Express, 7 September 2019. New Delhi
Joint Admission Board (2017). "Bridging Gender gaps in IITs". Ministry of Education https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1496395
Khobragade, S. P., & Kale, K. V. (2016). School mapping system using GIS for Aurangabad city. J. IJIRCCE, 4(10), 17110-17119.
Kumar S. (2021). Higher education and Knowledge Based Industries in India: UnderstandingGeographical Preferences, In P. K. Chaudhary & S. Babu (Eds.), Contextualising Educational Studies in India - Research, Policy and Practices, Routledge Publications. (pp.169-186),
Loyalka, P., Carnoy, M., Froumin, I., Dossani, R., Tilak, J. B., & Yang, P. (2014).Factorsaffecting the quality of engineering education in the four largest emerging economies. Higher Education, 68(6), 977-1004
Mehrota & Santosh (2015). "China's Skill Development System: Lessons for India." Economic and Political Weekly, vol. 50, no. 28, pp. 57–65
Menon, K. (2014). A Study on Employability of Engineering Students in Mumbai and Pune Region. Desertation Thesis for Master of Philosophy in Business Management, DY Patil University, Navi, Mumbai
National Commission on Population.(2020).Report of Technical Group on Population projection2011-2036.Ministry of Health and Family Welfare. Government of India.https://main.mohfw.gov.in/sites/default/files/Population%20Projection%20Report%202011-2036%20-%20upload_compressed_0.pdf
National Geographic Website, Geographic Information System, accessed on 18th July 2021,https://www.nationalgeographic.org/encyclopedia/geographic-information-system-gis/
National Institutional Ranking Framework.(2021).Ministry of Education, Government of India. https://www.nirfindia.org/2021/EngineeringRanking.html
National Remote Sensing Centre (NRSC). ISRO. website accessed on 19th July 2021.https://www.nrsc.gov.in/

National Statistics Office.(2019-20).Ministry of Statistics and Programme Implementation, Government of India. https://m.rbi.org.in/scripts/AnnualPublications.aspx?head=Handbook%20of%20Statistics%20on%20Indian%20States

National Testing Agency (2021). Department of Higher Education, Ministry of Education, Government of India https://nta.ac.in/Download/Notice/Notice_20210308221832.pdf

Nayar, D. P. (1970). Problems of technical education. Economic and Political Weekly, 533-539

Nilsson, S. (2010). Enhancing individual employability: the perspective of engineering graduates. Education+ Training

NIT-Patna website. (2021). Accessed on December 27, 2021. http://www.nitp.ac.in/php/home.php

Olfindo, Rosechin (2018). Rethinking Vocational Education in the Philippines: Does It Really Lead to Higher Wages?. Journal of Southeast Asian Economies, vol. 35, no. 1, pp. 79–100

Palit,K.S.(1998).The development of Engineering and Technical Education in India. Hlobal J. of Engng. Educ. Vol 2, No. 3.Printed in Australia

Pais-Montes, C., Freire-Seoane, M. J., & López-Bermúdez, B. (2019). Employability traits forengineers: A competencies-based approach. Industry and Higher Education, 33(5), 308-326.

PLFS(2018-19). Government of India, Ministry of statistics and program implementation, National Statistical Office, Periodic labour force survey 2018-19.Annual Report

Razali, N. M., & Wah, Y. B. (2011). Power comparisons of shapiro-wilk, kolmogorov-smirnov, lilliefors and anderson-darling tests. Journal of statistical modeling and analytics, 2(1), 21-33.

Sabde, Y D, Diwan, V., Saraf, V S, Mahadik, V. K., Diwan, VK & De Costa, A (2011). Mapping private pharmacies and their characteristics in Ujjain district, Central India,BMC health services research, 11(1), 1-8

SHL (2019). National Employability Report-Engineers, Annual Report https://www.shl.com/wp-content/uploads/en-national-employability-report-engineers.pdf

Supuwiningsih, N. N., Santosa, A., NymUtamiJanuhari, N., & Putra, A. (2018).Geographic Information System of Higher Education Mapping in Bali Island Using Arcview, International Journal of Engineering Technologies and Management Research, 5(5), 167-178

Tilak, J. B., & Choudhury, P. K. (2021).Employment and employability of engineering graduates in India. Journal of Contemporary Educational Research, 5(3)

Tilak, J. B., & Choudhury, P. K. (2021). Paradoxes and contradictions in the growth of engineering education in india,challenges and prospects, Working paper CSD 1/2021

UGC (2008). Higher Education in India, issues related to expansion, Inclusiveness, Quality and Finance

UGC (2018).Higher Education All India and state profile 2017-18

UGC (2021). University Grants Commission (Academic Collaboration between Indian and Foreign Higher Education Institutions to offer Joint Degree, Dual Degree and

Twinning,Programmes)Regulations,2021. https://www.ugc.ac.in/pdfnews/4258186_Draft-UGC-Academic-Collaboration-with-Foreign-HEIs-Regulations-2021.pdf

UN(2015). Department of Economic and Social affairs, The 2030 Agenda for Sustainable Development

UNESCO(2016).Strategy for Technical and Vocational Education and Training 2016-2021. https://en.unesco.org/sites/default/files/tvet.pdf

UNICEF(2019).Global Business coalition for Education, The 2030 Skill scorecard. https://gbc-education.org/wp-content/uploads/2019/09/GBC-Education-2030-Skills-Scorecard.pdf

Upreti, P.M. (2018). Engineering crisis" The Hindu Business Line 11 May 2018, New Delhi

Usher, A., & Medow, J. (2010). Global Higher Education Rankings 2010 Affordability and Accessibility in Comparative Perspective

VVOB vision on Quality Education. Accessed on 27th September 2021 https://www.vvob.org/en/education/our-vision-on-quality-education

Wheebox(2021). India Skills Report, https://indiaeducationforum.org/pdf/ISR-2021.pdf

World Economic Forum (2020). Reskilling Revolution https://www.reskillingrevolution2030.org/

World Bank, Government of India. (2017). TEQIP. https://www.teqip.in/

Zaharim, A., Yusoff, Y., Omar, M. Z., Mohamed, A., & Muhamad, N. (2009).Engineering employability skills required by employers in Asia. In Proceedings of the 6th WSEAS international conference on Engineering education (Vol. 1, pp. 194-201).

Annexure

Annexure-1

CONCEPTS AND DEFINITIONS

HIGHER TECHNICAL EDUCATION

For the purpose of this research paper, Higher Technical Education is defined as engineering education, which is obtained after completing 12 years of schooling or equivalent and is of the duration of at least four years (full time), or at least three years (full time) for students with lateral entry (students directly entering into second years of engineering).

HIGHER TECHNICAL INSTITUTIONS

All institutions, where higher technical institutions as defined above, is imparted was covered in this research paper.

INDUSTRY 4.0

It is name for the current trend of automation and data exchange in manufacturing technologies, including cyber-physical systems, the internet of things, cloud computing and cognitive computing and creating the smart factory.

NSDP

It is the net value of all the goods and services produced within a country's geographic borders.

URBANIZATION

As per Census 2011, an area defined as urban if it has minimum population of 5000, at least 75 percent of the male main working population engaged in non-agricultural pursuits and a density of population of at least 400 persons sq. km.

Annexure-2

ABBREVIATIONS

AICTE	All India Council For Technical Education
ASEAN	Association of South East Asian Nation
B.Tech	Bachelor of Technology
BITS	Birla Institute of Technology and Science
BHU	Banaras Hindu University
CS	Computer Science
ECE	Electronics and communication engineering
GER	Gross Enrollment Ratio
HoD	Head of the Department
IIT	Indian Institute of Technology
IOT	Internet of Things
ISRO	Indian Space Research Organization
MIT	Muzaffarpur Institute of Technology
MOOC	Massive Open Online Courses
MoU	Memorandum of Understanding
NIT	National Institute of Technology
NPTEL	National Programme on Technology Enhanced Learning
PG	Post-graduate
PhD	Doctor of Philosophy
PSU	Public Sector Undertaking
RTI	Right to Information Act 2005
SRM	Sri Ramaswamy Memorial Institute of Science and Technology
SWAYAM	Study Webs of Active Learning for Young Aspiring Minds
TPO	Training and Placement officer
UG	Undergraduate
UG	Undergraduate
VIT	Vellore Institute of Technology
VLSI	Very Large Scale Integration

Annexure-3

STATE WISE DATA ON URBANIZATION, NSDP AND FACTORIES

S.no.	State	*Urbanization (%)	#PC-NSDP	@NSDP	$Factories
1	Andhra Pradesh	33.5	168480	87006430	16739
2	Arunachal Pradesh	22.7	169742	2564801	115
3	Assam	14.1	86801	29956920	5020
4	Bihar	11.3	45071	54337663	3422
5	Chandigarh	97.3	330015	3917275	233
6	Chhattisgarh	23.2	105089	30799515	3576
7	Delhi	97.5	376221	75375917	3376
8	Goa	62.2	435959	6735570	708
9	Gujarat	42.6	213936	144768273	26842
10	Haryana	34.8	247628	70836363	11835
11	Himachal Pradesh	10	190407	13951123	2691
12	Jammu and Kashmir	27.2	102789	14358554	1000
13	Jharkhand	24.1	77739	29319200	2857
14	Karnataka	38.6	223175	147527677	13789
15	Kerala	47.7	221904	77309933	7696
16	Madhya Pradesh	27.6	103288	85623827	4640
17	Maharashtra	45.2	202130	248253582	25972
18	Manipur	30.2	84746	2914768	197
19	Meghalaya	20.1	87170	3104990	148
20	Mizoram	51.5	187327	2244179	
21	Nagaland	29	120518	2611622	187
22	Odisha	16.7	110434	48344801	3063
23	Punjab	37.5	155491	48234744	12825
24	Rajasthan	24.9	115492	89914304	9424
25	Sikkim	25	403376	2690518	84
26	Tamil Nadu	48.5	213396	161971992	38131
27	Telangana	38.9	233325	87137381	15167
28	Tripura	26.2	125675	5042066	621
29	Uttrakhand	30.6	202895	22758680	3002
30	Uttar Pradesh	22.3	65704	149575799	15854
31	West Bengal	31.9	113163	110065072	9420

**Source: Census 2011*

#Per capita net state domestic product at current price in rupee for 2019-20, as per National Statistical Office (NSO), Ministry of Statistics and Programme Implementation, Government of India

@Net state Domestic Product 2019-20 in lakh, as per NSO

$State wise number of Factories as per Annual survey of industries for 2018-19

Annexure-4

INTERVIEW GUIDE

(Director/Dean/Registrar/Administrative Officer/Head of the Department/Faculties)
Interviewer: Research Scholar at NIEPA, New Delhi

A. Profiling (Only for research purpose, personal identity will be kept confidential)

1. Name of Institution:
2. Name of Department:
3. Name:
4. Gender:
5. Designation:
6. Contact Number (optional):
7. Domicile (State):
8. Total Work Experience (in Years):

B. Participation:

9. How do you see the participation of youths of Bihar in engineering education?
    a. With respect to population?
    b. With respect to gender?
10. Participation of disadvantaged groups (SC/ST/OBC/EBC)?
11. Is location of engineering institutes impacts the participation or enrollments?
    a. Location within or outside state?
    b. Location within the division/district?
12. If an engineering student moves out of state for admission, what could be the reason? (Prompts: his/her preference or lack of choice in the state/quality education/ Infrastructure)
13. What are the factors which decide the enrollment/participation of students in engineering education?
    a. Placement rate?
    b. Management type?
    c. Other factors?

C. Availability:

14. As per AICTE data, Bihar has 57 engineering and technology institutes in 2021-22. Do you think that the state needs more engineering institutes?
    a. Which region?
    b. How many?
    c. Private/Government?
15. Should we focus on expanding the intake capacity of existing institutes rather creating new institutes?
16. Are these institutions rationally/evenly distributed across the regions of Bihar?

17. Do you think that sufficient number of seats is available at post-graduate and doctorate level in the state?
18. What are the factors which decide the establishment of engineering/technical institutes in a region?
    (Prompts: As per AICTE, for the year 2021-22, Bihar has 57 engineering and technology institutes while Tamilnadu has 494)

    D. Quality of Education:
19. What is the reason for seats going vacant in many engineering colleges?
20. What are those engineering disciplines which need to be added or removed in the state engineering institutions, as per the changing needs of industries?
21. Do you think the present engineering syllabus needs to be updated?
    a. At what period?
    b. Authority to revise syllabus?
22. What could be done to improve the skill and employability of engineering students?
23. Bihar has legacy of hosting ancient world famous Nalanda University. The state shares international border with Nepal. Do you think that the state has potential to become hub for engineering education even for foreign students, if quality technical education is provided?

Annexure-5

SEMI-STRUCTURED QUESTIONNAIRE

- Name of Institution:
- Name of Department:
- Name:
- Gender:
- Designation:
- Contact Number (optional):
- Domicile (State):
- Total Work Experience (in Years):

Rating on Likert Scale
Kindly rate these statements on scale of five,

Where: 1= (SD) Strongly Disagree
2= (D) Disagree
3= (U) neither Agree nor Disagree
4= (A) Agree
5= (SA) Strongly Agree

Statements		Agreement Scale				
		1	2	3	4	5
		SD	D	U	A	SA
LH1	The state has sufficient number of technical institutes.					
LH2	The intake at under-graduate level in the state for technical education is sufficient with respect to population.					
LH3	The intake at post-graduate level in the state for technical education is sufficient with respect to population.					
LH4	The intake at doctorate level in the state for technical education is sufficient with respect to population.					
LH5	The technical institutions in the state have all the relevant disciplines (branches).					
LH6	The technical institutes in the state are rationally distributed across the region.					

	Items	Agreement Scale				
	Below mentioned items, could be the factors which influence the location (establishment) of technical/engineering institutes in a state/region. Kindly rate these factors on scale of five. [1= Strongly Disagree (SD), 2= Disagree (D), 3= Neither Agree Nor Disagree (U), 4= Agree (A), 5= Strongly Agree (SA)]	SD 1	D 2	U 3	A 4	SA 5
AF1	Government expenditure on technical education					
AF2	Government policy					
AF3	The state's government administrative machinery and the law and order situation					
AF4	The availability of social infrastructure like electricity, connectivity etc.					
DF1	Population in the age group 18-23 of the state					
DF2	Social demand (number of registrants for engineering entrance exam)					
DF3	The admission rate/enrollments in technical institutes					
DF4	The ideological preference for technical education among parents and students					
EF1	The per capita income in a state					
EF2	The level of employment among technical graduates					
EF3	The presence of knowledge based industries in a state					
EF4	The degree of urbanization in a state					
ERF 1	The existing number of technical institutes in the region					
ERF 2	The availability of qualified faculties					
ERF 3	The literacy rate in the state					
PF1	The availability of land					
PF2	The geography of a region (hilly terrain/plain area)					

One open ended question

What are the other factors which determine the location and distribution of technical institutes in a region/state?