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Editorial

Higher Education in India particularly engineering education system still following old practices of Teaching-Learning (T-L) methods and unable to process and train the students and make them skilled graduates to meet the industrial requirements. Many talented graduates prefer to move abroad to pursue their higher studies due to various reasons. IITs and NITs can play an excellent role in grooming the faculty working in higher education institutions in India to improve the quality of education.

Solar Energy is the way of the future since it is clean, green and sustainable in nature. Solar cells that convert light energy into electricity are available at an affordable price now a days. Another advantage of solar system is it can be used wherever people wish to live and also in a place where no electricity available. In this context, some of the state governments encouraging the people and making mandatory to install solar panels at their roof tops to obtain building occupancy certificate from the town planning department.

This edition of IJTE contains articles on “IITs and NITs as Leader in Engineering Education in India to Become World Class: Internal Activities and Issues (I)”, Atmnirbhar Bharat : Ease of Doing Business”, “Smart Management System for Efficient Supply and Distribution of Drinking Water”, “Effect of Nutritious Food and Yoga Training on Coordination of Malnourished Students”, “Regional Distribution of Foreign Direct Investment Inflows to India”, “The Implications of IoT on Photovoltaic (PV) Solar Energy”, “Learners’ Activism on E-Learning : A Case Study”, “Studies on Unconfined Compressive Strength of Chemically Treated Bio-Enzymatic Soil”, QSPR Analysis of Antibiotics used to Treat Tuberculosis Topological Indices” etc.

We take this opportunity to thank all authors for their contribution of manuscripts and reviewers in making this issue more informative and useful to the readers. Suggestions and feedback from our readers are highly appreciated to improve the quality of journal.

New Delhi **Editorial Board**
31st December, 2022

IITs AND NITs AS LEADER IN ENGINEERING EDUCATION IN INDIA TO BECOME WORLD CLASS : INTERNAL ACTIVITIES AND ISSUES (I)

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ABSTRACT

This article comprehensively presents strength, weakness, opportunity and threats (SWET) of IITs and NITs based on Author's experience and critically compares the two systems that form major pillars of Engineering Education in India. All major aspects of their activity are covered. They attract best faculty and students and receive good funding and patronage from Indian government. Outcome of their Bachelor, Masters and Doctoral programs are tending to be of global level as they now have a critical mass to compete with World's best. Synergy between 23 IITs and 31 NITs combined with healthy competition among them is proposed towards visible National and Global impact and be part of the grand ambition to make India a knowledge superpower with strong economy. Steps needed to bridge the gap between the two are suggested as also to reach higher world ranking. Their role in implementing National Educational Policy (NEP) 2020 is also discussed. Part-I discusses internal activities while Part-II deals with outreach activities.

1. INTRODUCTION

Engineering is a prime necessity of civilization to produce goods, services and systems to meet human needs relating to food, shelter, clothing, transportation, energy, communication, security, entertainment, environment, health etc. Needs that were minimal and sustainable at the dawn of civilization have grown manifold at present due to revolutionary scientific and technological discoveries and innovations, thus converting 'needs' to 'wants.' Engineering Education has become a major part of the Education system to produce Engineers with needed skills, knowledge and Expertise. Since Engineer has to develop systems acceptable to society for quality living, such an education must encompass apart from core Engineering areas Science, Humanities, Soft skills, Management, Economics, Law and Ethics. As needed manpower had to be produced ever since man wanted good life, we may chronologically look at the broad genesis of Education in India. Education broadly encompasses Knowledge dissemination (Teaching), Knowledge assimilation (learning) and Knowledge generation (Research). Since Upanishadic times Education has been India's forte with intense interaction between teacher (Guru) and taught (Shishya) under the 'Gurukul' system popularly known as 'Guru-Shishya Parampara' (Teacher- student heritage) where both stayed together and studied. Broadly education had two components, one for quality living and other for quality life. First dealt with materials (external) and

second with mind (internal). First was to give comfort and the second happiness. They even branded first as 'Apara Vidya' and second as ' Para Vidya'. While they agreed that first was essential for good living, second was considered true knowledge dealing with human values and bliss. Saints and sages preached the second system with considerable emphasis on 'mind management' like Yoga and meditation. 'Science and Technology' comes under the first category which is considered 'essential' today though not 'sufficient' keeping in view man made 'Covid' and 'climate change' catastrophes. Centre of Excellence for Indian Knowledge Systems(CEIKS) of IIT Kharagpur has collated considerable data on enormous accumulated knowledge treasure created in ancient India over nearly 5000 years through structured and non structured educational systems of yore.

Documentary in Reference [1] details contribution to Science and Technology in Ancient India referring to Vedic sources. Lecture in youtube by Subhash Kak [2] is highly informative on Indian contribution to Science. NEP[3] (Sec.11.1) quotes the strength of Education in Ancient India as follows: "Ancient Indian literary works such as Banabhatta's Kadambari described a good education as knowledge of the 64 Kalaas or arts; and among these 64 'arts' were not only subjects, such as singing and painting, but also 'scientific 'fields, such as chemistry and mathematics, 'vocational 'fields such as carpentry and clothes-making, 'professional 'fields, such as medicine and engineering, as well as 'soft skills' such as communication, discussion, and debate." Thus there is enough evidence of impressive education system in Ancient India involving studies on Science, Technology, Mathematics, Cosmology, astronomy, Health Sciences, Earth, terrestrial and environment sciences, Logic, Law & governance, Economics, chemical sciences, metaphysics, Biological Sciences, Dance/Music/Art, Weaponry/Marshal Arts, Theology, Philosophy, architecture and sustainable living [1]. Above remarkable contribution to knowledge is acclaimed by many western scholars like A L Basham, Will Durant, Einstein, Mark Twain, James Duff, Romain Rolland, Arnold Toynbee, Max Muller, Alice Boner and Voltaire..

Unfortunately above storehouse of knowledge on Science and Technology in Ancient India is not even mentioned in the current Education system either due to ignorance or by deliberate design while most information is sourced from west. Varhamihira did detailed study on planetary systems 2500 years ago but rarely referred in modern texts on the subject. In the fifth chapter of Vaisheshika Sutra Sage Kanaada (6^{th} century BC) propounds Laws of gravity and motion repeated by Newton in 16^{th} century AD. Kanaada's work is rarely quoted in current science books that only highlight Newton. This fact is confirmed by Manchester University[1]. Bhaskaracharya gave the whole concepts of the universe comprising stars, planets and solar system. Indians knew that Earth and other planets were round much before west started debating it. Varahamihira too introduced concept of gravity. Galileo discovered laws of Kinematics and recorded in his book " Two New Sciences" 1100 years after Aryabhatta propounded the same mentioned in his work "Aryabhatia". 'Agamas' written thousands of years ago are treaties on theology, Epistemology and details Temple architecture involving intricate geometries, which are followed even today. Agamas reveal hidden Mathematical marvels and 'Shilpa Shastra' explaining sculpting of stones for a structure. Number system and unit of length and time were amply used in ancient Indian scriptures much before west started to count.

It is well known that universities like Nalanda and Taxila were great centres of learning that attracted scholars from all over the world. Science Museum in London has a poster mentioning that Indians built rockets before British that were used against British army. Indian textiles were famous for centuries. Londoners were eagerly waiting for the weekly ship from India bringing Indian Textile goods. Education System in India had a major dent during nearly thousand year of foreign rule before independence, as many rulers were not keen to educate the public. History is replete with events of subjugation and slavery with little information on education, science or technology. India missed Industrial Revolution that pulled her back in Engineering, Technology and manufacture compared to west. Mahatma Gandhi [4] addressing

Royal Institute of International affairs, London on 20th Oct.1931 mentions- "India today is more illiterate than it was hundred years ago because British administrators when they came to India instead of taking hold of things as they were, began to root them out.... Ancient schools have gone by the board because there was no recognition for these schools and schools established after the European pattern were too expensive for the people... "By the time of these comments, Universities of Calcutta, Madras and Bombay existed for over half a century (By 1947 there were 21 universities in India). Swami Vivekananda who inspired JRD Tata to establish Indian Institute of Science (IISc) and a Guru of great scientist Tesla[2] on education has said [5],- " The child is taken to school, and things he learn are that his father is a fool, grandfather a lunatic, all teachers are hypocrites, all sacred books are lies! By the time he is sixteen he is a mass of negation, lifeless and boneless. And the result is that fifty years of such education has not produced one original man in the three Presidencies." On technical education, very little information is available on teaching of techniques and crafts in 18th or early 19th century. Gradually crafts were learnt at home, passed on within the same caste, parents usually being teachers and children the learners.

Engineering Education formally started in India during mid nineteenth century [4] and largely followed the practice-oriented pattern of pre-war British education even in the post World War II era up to early years of independence. Engineering jobs were mainly confined to Public Works Departments (PWD), Electricity Boards, Posts and Telegraph, Railways and ordnance factories all in government sector. By 1947 India had 28 polytechnics and 28 Engineering colleges to provide Engineers and technicians for operation and maintenance of equipment and systems largely imported from West.

With the above fragile background India dreamt of World Class Engineers and World class Institutions post independence, which was a great challenge. In this direction, Indian Institutes of Technology (IITs) and National Institutes of Technology (NITs) form TWO major pillars of Technical Education in India, each having their own genesis and growth till date. This article is based on Author's experience of over four decades of teaching in IIT Delhi and having served as founder Director of NITK Surathkal. There are 23 IITs and 31 NITs as on date that attract best students and teachers and form the largest group of premiere Engineering Institutions in the world under a common umbrella with a critical mass having potential to become the strongest cumulative knowledge storehouse in domain areas. Despite this strength the country is lamenting why they do not find place among top world ranking even compared to newly developed countries like China and Singapore. To achieve declared National objective of 'Atmanirbhar Bharat', 'Make in India' and 'developed India' above institutions can play a crucial role, but their contribution to technical and economic development of the country is not found very significant compared to similar institutions in developed world. We must critically assess their strengths and weaknesses through 'compare and contrast' to enhance their National impact. This article comprehensively presents a SWOT (Strength, Weakness, Opportunity and Threat) analysis on IITs and NITs that may help reframe our policies for future actions. Almost all aspects of their functioning are discussed.. This paper (Part-I,II) provide a clear guideline how these institutions can come up to the level of top ranked world universities.

'Profile of Engineering Education in India' [5] authored by Gautam Biswas. KL Chopra, CS Jha and DV Singh for Indian National Academy of Engineering (INAE) is among the best scholarly documents published so far on Engineering Education and its reading is a must for all those interested in the subject.

NEP- 2020 [3] dealing with higher education and professional education (pp 33-50) provides several novel ideas for IITs/NITs to ponder and act as discussed in this paper. IITs and to lesser extent NITs have been regularly adopting several Education reform measures mentioned in NEP. IITs have adopted several measures recommended by NEP much earlier and in effect have been ahead of NEP. IITs/NITs are in a crucial position to steer National actions on NEP especially on Technical Education.

Some of the possible measures are mentioned in this article. NEP(Sec.9.2) mentions major problems of Higher Educational Institutions (HEI) as below:

(a) a severely fragmented higher educational ecosystem;

(b) less emphasis on the development of cognitive skills and learning outcomes;

(c) a rigid separation of disciplines, with early specialization and streaming of students into narrow areas of study;

(d) limited access particularly in socio-economically disadvantaged areas, with few HEIs that teach in local languages

(e) limited teacher and institutional autonomy;

(f) inadequate mechanisms for merit-based career management and progression of faculty and institutional leaders;

(g) lesser emphasis on research at most universities and colleges, and lack of competitive peer-reviewed research funding across disciplines;

(h) suboptimal governance and leadership of HEIs;

(i) an ineffective regulatory system; and

(j) large affiliating universities resulting in low standards of undergraduate education.

It is refreshing to note that IITs are free from most of the above problems and hence ahead of NEP though some marginal improvement may be possible in some of the issues such as c &d. Sec.9.1.1 of NEP states " Given the 21st century requirements, quality higher education must aim to develop good, thoughtful, well-rounded, and creative individuals. It must prepare students for more meaningful and satisfying lives and work roles and enable economic independence." IIT education already provides for these traits as proven by the alumni. Listed visions of NEP (Sec.9.3) are:

(a) moving towards a higher educational system consisting of large, multidisciplinary universities and colleges, with at least one in or near every district, and with more HEIs across India that offer medium of instruction or programmes in local/Indian languages;

(b) moving towards a more multidisciplinary undergraduate education;

(c) moving towards faculty and institutional autonomy;

(d) revamping curriculum, pedagogy, assessment, and student support for enhanced student experiences;

(e) reaffirming the integrity of faculty and institutional leadership positions through merit-appointments and career progression based on teaching, research, and service;

(f) establishment of a National Research Foundation to fund outstanding peer-reviewed research and to actively seed research in universities and colleges;

(g) governance of HEIs by high qualified independent boards having academic and administrative autonomy;

(h) "light but tight" regulation by a single regulator for higher education;

(i) increased access, equity, and inclusion through a range of measures, including greater opportunities for outstanding public education; scholarships by private/ philanthropic students; universities for disadvantaged and underprivileged; online education, and Open Distance Learning (ODL); and all infrastructure and learning materials accessible and available to learners with disabilities.

IITs/NITs have taken positive steps on some of the above issues such as b,c,d,e,i as highlighted in following sections though there is enough scope for improvement while effective steps need to be taken by government on f,g,h.

2. EVOLUTION OF IITS

In pre-Independent era a committee under the chairmanship of N.R.Sarkar was constituted in 1945 to consider the development of higher technical institutions in India. [https://en.

wikipedia.org/ wiki/Indian_ Institutes_of_ Technology]

Sarkar committee recommended setting up of at least four higher technical institutions similar to MIT of USA one each in North, South, East and West to produce 'creative scientist-engineers'. Post- independence, above recommendation was followed up to set up Five IITs starting from Kharagpur (1951) followed by Bombay (1958), Kanpur(1959) Madras (1959) and Delhi (1961), the last four with Russian, American, German and British collaboration respectively. These five core IITs created a unique culture and stood apart for over half a century through outstanding teaching, research and outreach attracting best students and faculty and rose to global fame. They made India proud cited by American presidents and UN.

A special one-hour TV program on IITs was aired in USA which attracted wide audience. They were trendsetters for technical education in India. Consequent to Rajiv Gandhi's Assam accord IIT Guwahati was established in 1994. Formation of a separate state of Uttarakhand gave impetus to converting University of Roorkee to IIT in 2001 with a big push from then HRD Minister Murli Manohar Joshi. With explosive demand from brightest school leavers for IITs through the famous Joint Entrance Examination (JEE), expansion of IIT system became inevitable. Due to cut-throat competition for limited IIT seats coaching industry expanded beyond imagination and students developed mercenary traits at the cost of formal education. In an article written about a decade ago former Education Secretary Ashok Thakur mentions the annual cumulative turnover of coaching industry as Rupees 1.25 lakh crores which is perhaps more than the budget of higher education. For each 'IIT-selected candidate' large number of equally competent ones were left out and frustrated. Consequently, eight new IITs were started in 2008/ 2009 mentored by old IITs at Ropar (Punjab), Jodhpur (Rajasthan), Gandhinagar (Gujarat), Bhubaneswar (Odisha), Patna (Bihar), Hyderabad (then AP), Mandi (HP) and Indore (MP) and the trend was to have one IIT in each major state. This expansion process continued with IT BHU converted to IIT in 2012 and two IITs came up in south in 2015 at Tirupathi (as demanded by the new state of AP) and Palakkad (Kerala). Still geographical distribution of IITs was not uniform with clusters in some region needing to be rectified. Thus in 2016 new IITs were set up at Bhilai (Chhattisgarh), Goa (Goa), Jammu (J&K) and Dharwad (Karnataka) and ISM Dhanbad (Jharkand) was converted to IIT completing the process with a total of 23 IITs leaving only Haryana without an IIT though IITD has a campus there. Political pressure was often in play in deciding location of new IITs in each state ignoring academic factors. Air connectivity was essential to attract faculty, industry liaison and global reach. Most of the IITs are well located being in state capitals or major cities and close to major airports. IITs at Kanpur, Kharagpur and Mandi are still facing connectivity problems. A few IITs are located at a short distance apart such as Chennai-Tirupati, Goa-Dharwad, Ropar-Mandi. There are two IITs in UP, perhaps an exception made for a big state.

Eighteen new IITs as distinct from the old five faced (some still facing) several challenges. Converted IITs at Roorkee, Banaras and Dhanbad had their old 'baggage' with some inherent resistance to get into IIT 'grove'. We should remember that they have a long History having started in 1847, 1919 and 1926 respectively. Thus they had their strengths too which cannot be sacrificed. Slowly amalgamation is taking place as they bring in their color and personality in the 'basket'. IIT Guwahati did not face such problem as it started from a clean slate. It has now come on its own and catching up with old IITs. Since most of the Directors of new IITs were drawn from the old 'Five', IIT culture could be brought in. Mentoring by old IITs too helped while giving them freedom to try new experiments. Still it is a long journey and some may take several years to catch up and be on par with their 'elder brothers'. Directors of these IITs must be given considerable freedom (and resources) to 'run fast' and MHRD (now MoE) should play a very supportive role. We must draw lessons from the positive process through which old IITs grew in formative years and new IITs must have a similar smooth process. Building new campuses is a challenging task and an opportunity. IITs started in 2008 have moved to

new campuses and recent ones (2015/16) are busy building them. New IITs also have great opportunity to tread distinct paths and create niche personality distinct from old ones. I found many young faculty in new IITs very enthusiastic in building their institution and they must be made to feel the ownership. I found their Directors committed not to sacrifice quality of faculty recruited. The 23 IITs must be like a bouquet of flowers each with a pleasant and distinct color/fragrance and proudly owned by the country. For this IIT system must not deviate from its core values of Excellence and Integrity.

3. EVOLUTION OF NITS

Apart from setting up IITs, a major decision of Indian Government towards quality technical education was to establish Regional Engineering Colleges (RECs) in each state jointly with concerned local government.[https://en.wikipedia.org/wiki/National_Institutes_of_Technology]

Earliest RECs were set up during 1959-61 at Warangal, Surathkal, Calicut, Surat, Srinagar, Allahabad, Bhopal, Rourkela, Durgapur, Jamshedpur and Nagpur followed by Jaipur & Kurukshetra (1963), Trichy (1964). Silchar was added in 1967 and Hamirpur, Jalander in 1986,1987. These 17 RECs functioned successfully till end of the century attracting good students, faculty and placement. They had good infrastructure and campuses some even comparable to IITs. They were rated as best engineering colleges in respective states. In 1998 a "High Powered Review Committee" (HPRC), chaired by R.A.Mashelkar, submitted its report entitled "Strategic Road Map for Academic Excellence of Future RECs" based on which, then HRD Minister Murli Manohar Joshi decided to upgrade all existing RECs to "National Institutes of Technology" (NITs) in 2002.The upgrade was designed along the lines of the Indian Institutes of Technology (IITs) after it was concluded that RECs had potential as proven by the success of their alumni and their contributions in the field of technical education and that they were on par with the IITs. Subsequently, funding and autonomy for NITs increased, and they award degrees that have raised their graduates' perceived value. Conversion of RECs to NITs was a revolutionary step that unshackled them from the States and paved way for fast track growth with autonomy. In 2004, MHRD issued NIT status to three more colleges, located at Patna (Bihar Engineering College, a 110-year-old college), Raipur (Government Engineering College), and Agartala (Tripura Engineering College).There were thus 20 NITs till 2006.

3.1 NIT Act

For proper governance of NITs similar to IITs, it was necessary to draft and adopt the "NIT Act" by the Parliament and MHRD got down to this task. The concerned MHRD official took the easy way out and drafted the NIT act by just substituting "NIT" in place of "IIT" in the IIT act and sent it to Law Ministry for vetting before sending to Parliament. The smart Law Ministry noticed this 'short cut' and retuned the draft to MHRD with some strong observations. They opined that if IIT Act could be thus tweaked to draft NIT Act, a simple law could be passed by extending IIT Act to NITs. They insisted that NIT act must be distinct incorporating special features of NITs. I was then the Director of NIT Surathkal and got a call from MHRD requesting me to prepare a document listing similarities and differences between IITs and NITs to be embedded in the new draft of NIT Act, since I was familiar with the IIT system. I got down to the job and prepared a detailed document for MHRD which was incorporated in the draft. The new draft was approved by Law Ministry after detail internal deliberations and presented to Parliament. It was approved by the Parliament in 2007, All NITs were designated as Institutes of National Importance similar to IITs. The 21st (and the first brand-new) NIT was set up in Imphal in the north-eastern state of Manipur and the government announced setting up ten new NITs in the remaining states/territories. NITs in Arunachal Pradesh, Delhi, Manipur, Goa, Meghalaya, Mizoram, Nagaland, Sikkim, Puducherry, and Uttarakhand came up in 2010 and the Last NIT was set up in Andhra Pradesh consequent to formation of Telangana. There were 11 brand new NITs not converted from old RECs. This resulted in every state in India having its own NIT totaling 31 with 50% UG admissions to local students.

4. PROBLEMS OF GROWTH

Above expansion of IITs/NITs was a historic step towards major push to quality technical education in India as they have the potential and promise to compete with global best, though some have apprehension that the step might dilute quality as new ones would never reach the level of old iconic lot. I do not agree with this pessimism as some of the new IITs like Guwahati, Hyderabad, Indore, Gandhinagar and Ropar are already giving 'tough fight' to old 'brothers' as per current ranking. Expansion of IIT/NIT was a National necessity as the rejection rate of aspirants through JEE is highest for any Engineering admission in the world. This is a great challenge and opportunity for the new lot that need considerable handholding. Process of growth is not painless. Conversion of old institutions and setting up new ones need different strategies. 'Best Institutions are built by following best practices of Best Institutions'. This can be good guideline to new IITs and NITs. Good Faculty, Students, Infrastructure and Governance are critical and IITs excelled as they had all these while old RECs lacked good governance due to multiple controls. While infrastructure can be built with funds, attracting best faculty and students is a challenge to all institutes as this is a parameter reflecting their quality.

Best Institutions are those that attract best students and faculty and all IITs/NITs must strive for the same, more so the new ones. Converted institutions had their own baggage and it was desirable that they adopt best practices of IITs while retaining their own good practices and traditions. When I took over as the first Director of NIT Surathkal (on deputation from IIT Delhi) I made the above as a motto and pushed aggressively to adopt IIT practices and culture. There was opposition mostly from some senior faculty who were taken out of their comfort zone while young faculty was ready for change. Finally all fell in line and enthusiastically participated in reform. First challenge was to reform curriculum, credit system and teaching-learning philosophy. Several workshops were conducted with active participation from faculty that resulted in a new curriculum structured in IIT pattern. The foundation thus laid is yielding dividends today.

Some of the relevant issues for new IITs and NITs are discussed in following sections with possible action plan to bring them up to be leaders in Technical Education in India and compete globally.

5. ADMISSION PROCESS

Admission process for IITs and NITs has been continuously evolving since their inception and getting refined regularly. JEE has been a well-respected credible scheme for IIT admissions for decades. IITs were very possessive about it. It started as a normalizing test for candidates passing out from different boards pan-India and needed no additional coaching. Over the years coaching Industry has become a dominating influence on JEE outcome as even the bright and the best among the candidates are made to feel the need for extra coaching to succeed. Unwillingly IITs are feeding into this industry sustained by parents at a huge cost. Policy planners have tried to curb the role of coaching centers but in vain due to large number of aspirants with seats less than 10% of that number. In recent years JEE has undergone considerable reforms for the better. National Testing Agency (NTA) has been set up to conduct multiple online tests in a year to reduce 'chance' element. 'One Nation, One entrance test' must be the ideal for Engineering admission similar to NEET for medical and let us hope such a scheme will evolve soon. JEE (Main) score decides NIT admissions while IIT aspirants must take an additional JEE (advanced) test conducted exclusively by IITs.

Top merit list of second test may not differ widely from the first, which can be verified from the data of last few years. In that case it may be prudent to scrap JEE (advanced) since more test means a bane to students and boon to coaching industry. IITs have conducted JEE over past few decades with impeccable integrity and may have some trust deficit with NTA. This can be avoided by involving IIT expertise by NTA effectively to conduct JEE (main). Logic behind advanced test is that it separates the best from the rest. A better alternative could be to embed about 20% of advanced questions in the mains paper, which can be 'cracked' only by the bright and the best. There is no logic why NITs and IITs must have different tests

for selections. If only one test becomes basis for selection of both, a candidate has wider choice of Institution and branch and institutions may be ranked based on student choice- one may choose an NIT over an IIT based on location, branch and quality perception. This provides a common basis to compare all Institutions based on student choice. Combined counseling for IITs and NITs is in National interest and will be welcomed by students and parents. Ignoring Board score in selection is a great injustice to students and the boards that conduct such elaborate examinations. Since coaching has a bearing on JEE performance, equally bright students from rural and poor backgrounds who cannot afford coaching will be disadvantaged. Accounting board score will rectify this malady to an extent. A simple solution is to take the average of percentile of JEE and board examination and prepare a combined merit list. This requires that all Boards must provide percentile apart from absolute score. There is a contrast in the rigor of the above two tests taken by candidates- Board exam is designed to ensure maximum number to pass while JEE ensures maximum to fail. Thus combining the two performance of a candidate may be a leveler and just. We may look at the admission process in reputed American universities as a guide. There is only one National test (SAT) whose score is used in admissions only partly as they also factor school performance in addition to other attributes such as social service, co-curricular activities, and teacher recommendations etc. While combining several such qualities may not be practicable in India, combining scores of JEE and board is doable.

Table-1provides Category wise Cut off of total NTA Score in JEE(main), 2020 indicating wide variation across categories leading to heterogeneous composition of selected candidates. As per data on cut off JEE ranks Bombay, Delhi and Madras are the most preferred IITs due to their location and excellence followed closely by Kanpur and Kharagpur who suffer due to location. CSE is the most preferred branch followed by EE and ME. Among converted IITs, Roorkee is in lead followed by Banaras with Dhanbad fairly behind. Among 2nd generation IITs started a decade ago and with their own campuses Hyderabad, Gandhinagar, Bhubaneswar and Ropar appear to be ahead followed by Indoor, Patna, Jodhpur and Mandi. Hyderabad is ahead of Guwahati and catching up with Kharagpur while Gandhinagar too is catching up with Guwahati. Among 3G IITs Tirupati is ahead due to location closely followed by Dharwad and Palakkad. Bhilai and Jammu are in the bottom as per this ranking. It is now a challenge to these young IITs to build attractive campuses, hire quality faculty to perform well academically and attract students with higher rankings. With over 10 lakh students appearing for JEE, even a 10,000 rank student is among top 1% whose merit and potential must not be undervalued. Thus even 3G IITs facing teething troubles now will shine well over time. Candidates with ranks higher than 10000 may land up in less attractive branches of older IITs.

Open and closing ranks of a few NITs for 2020 admissions in open category is available in the link [https://josaa.nic.in/Result/Result/currentorcr.aspx]. Trichy is in the lead followed by Surathkal and Warangal chasing the above. Bhopal has to work hard to catch up with the above. Andhra being the latest NIT is getting candidates who are far behind those going to old NITs. Interestingly they are not far behind Bhopal. Warangal presently in Telangana has advantage over Andhra (both in old state of AP) as it is older. Over time Andhra may catch up with Warangal, being in the same region provided it attracts good faculty and excels academically. Normally top students from each state taking JEE

Table 1 : Category wise Cut off of total NTA Score in JEE(main), 2020

Category	Common Rank List (CRL)	Economically Weaker Section (EWS) (10%)	Other Backward Class (OBC)(27%)	Scheduled Caste (SC) (15%)	Scheduled Tribe (ST) (7.5%)
Score	90.3765335	70.2435518	72.8887969	50.1760235	39.0696101

(Main) opt for local NIT under HS seats. To compare different NITs OS ranking is a proper criteria. From available data through websites we notice that some of the popular NITs score over some 2G & 3G IITs for same branch. Therefore common counseling of NITs and IITs will provide better option for candidates and help ranking these good NITs vis a vis IITs. All 31 NITs must be provided 'level playing field' to have healthy competition to attract good students. New NITs must build attractive campuses, hire good faculty, and provide good governance to be able to catch up with the old lot. Some have locational handicaps. Even the old NITs widely vary in their position in attracting good students mainly due to varying quality and perception. This should be a matter of concern.

6. LEVEL PLAYING FIELD

Since these 54 premiere Institutions (IITs + NITs) are declared as Institutes of National importance, country expects all to become excellent to be leaders in technical education in India producing top class Engineers and compete globally to aspire for high ranking. It is ideal for the country to provide 'Level Playing Field' to all and expect healthy competition to excel. In reality most of the IITs enjoy level playing field with a few having locational handicaps. Thus over time all 23 IITs should be able attain similar levels of excellence. Historically first 5 IITs grew to almost same level. Now Roorkee, Banaras, Guwahati and Hyderabad are almost there. Slowly other 2G,3G and converted IITs can reach similar levels given equal opportunities and support. But road ahead is tough. Most critical factor is to search and recruit excellent faculty at this juncture as done in first five IITs.

Unlike IITs, NITs faced many disadvantages. Since RECs were varying widely in quality due to several factors including location, connectivity and state politics the converted NITs carried a huge baggage. Initially NIT salary scales for all positions including Director were lower than that of IITs, which attracted better faculty to IITs compared to NITs. Now this anomaly is corrected and NITs should work to get good quality faculty. Promotional avenues for NITs were restricted while IITs were liberal with norm of 'flexible cadre' that does not restrict number in any cadre within the total faculty strength of a department. NITs had only 'Career Advancement Scheme'(CAS) which too was subject to criticism by some sections citing arbitrariness and lack of transparency. This led to many court cases. CAS depended on integrity and fairness of the Director. At present NITs too have similar flexibility as IITs and CAS is abolished which is a good riddance. Thus NITs face level playing field in this front and should be expected to aspire IIT levels. Status of NITs vis a vis IITs in other critical parameters to reach academic excellence is presented below.

7. STUDENTS

Students are major stakeholders of an Institute. While quality of students decides the quality of Institute, best students opt for best Institutes which is the reason IITs and NITs attract the cream of JEE aspirants as they are branded best among technical Institutions in India.

While bright school leavers keen on engineering education join B.Tech in IITs /NITs through JEE, large number of equally bright ones opt out due to financial and personal reasons or unwilling to go through 'coaching' grill and end up in other local Engineering colleges. But for many of them dream of IIT is not diminished as the bright among them often end up in IITs for post-graduation. Thus IITs continue to be magnet for bright youngsters for engineering. While all school leavers entering IITs are bright, all bright school leavers do not enter IITs. Many of those missing out on IITs end up in NITs. Many will miss IITs by a whisker or not interested in branch they got. Nearly top 5% of JEE candidates end up in IITs and NITs with top layer opting for IITs. From my experience of dealing with students of IITs and NITs, I feel that IQ level of most of them is nearly same. Arguing on the difference between IIT and NIT B Tech students is a futile hair-splitting exercise. Many alumni of NITs(and former RECs) had brilliant professional carrier in India and abroad (some were IIT Directors too). But their training and exposure may not be of same level as IITs. Large number of them pursued their M Tech and Ph.D from IITs.

During initial periods of IITs students in a class had JEE ranks within a small band in the

absence of reservation. Class was homogeneous in competence levels needing teaching and testing at a high level in tune with student intelligence. This was true when I started teaching in IITD from 1970. We had to enter a class with high level of preparation to excite these bright students; any mistake in our delivery would be caught by one student or other. After a few years SC/ST reservation was introduced followed by OBC reservation in early 21st century. Thus by design nearly 50% students in a class had JEE ranks fairly below those of open category. Thus classes became heterogeneous in competence needing some compromise on teaching and testing levels. Some teachers faced a dilemma, as teaching to suit top segment in a class would make comprehension by bottom layer difficult while teaching at a lower level to suit bottom students would make it uninteresting to top students necessitating a balancing act. Situation may be similar in NITs too.

Recently there is a new phenomenon of many school leavers opting to go abroad for Bachelors programs from their own funds or taking Bank loans at an investment of about Rs.50 lakhs per year. They need not be best brains comparable to IITians, but rich and motivated for foreign degree which may lead them to a foreign job. Even if we guess that about a lakh of self-supporting students go abroad each year, the foreign exchange drain is huge. As per RBI data (Times of India Aug.2, 2021) foreign education accounts for most outward remittances. Total remittance was $18.8bn for 2020. Monthly remittance for education was $79Mn in Apr.2020 which went up to $353Mn in Apr.2021. There is no data on how much of this money is ploughed back. Most of these students tend to stay back abroad after studies not only to clear loan but for the glamour of western life. It is a one-way traffic. Apart from clearing loan there is little chance of them sending money to India to help the economy. It is not always that they get admitted to the best of foreign universities as many enter inferior campuses whose level may be lower than some of the best Indian Institutes. IIT/NIT should be better option for such motivated students. Indian students find it lot easier to crack the US entrance test SAT than JEE. Getting admission to US universities is thus relatively easy if one can afford. It is a challenge for IITs/NITs to attract foreign bound Indian students. Recent UGC scheme to permit foreign universities to open campuses in India will reverse the above trend for the good of the country.

Regarding M.Tech. or postgraduate students IITs distinctly score over NITs. IITs attract bright B Techs from other engineering colleges including NITs through Graduate Aptitude Test (GATE). NITs are not attracting bright GATE scorers similar to IITs. Thus M Tech programs (including Theses) of IITs are generally superior compared to NITs. IIT Masters programs tend to be distinct too while most of the NITs have 'run of the mill' M Techs. Thus NITs have to make considerable effort to make their M Techs on par with IITs and attract good students. Since GATE score is also a basis for selection to Public Sector Undertakings (PSUs) M Tech attrition has increased.

Story of Doctoral students is still different. IITs are struggling to get bright and motivated research scholars in engineering. Bright M Techs from IITs normally do not opt for PhDs unless they are highly motivated or inspired by the guide or without any other option. Best catch for IITs are those joining PhD on deputation such as QIP scholars who are teachers from other engineering colleges including NITs under Quality Improvement Program (QIP). NITs too have QIP centres but may not get quality research students. Some teachers without PhD in NITs often register locally towards PhD. Their number is dwindling. There are still active NIT professors guiding research but handicapped by not getting good scholars. This is a great challenge to NITs who need to make rigorous effort to improve to catch up with IITs. Sponsored projects may be a route to get scholars in IITs and NITs. This needs faculty to submit projects and succeed in getting funds to support scholars.

8. FACULTY

Faculty is the most critical component of IIT/NIT system to sustain, nurture and promote excellence. During formative years of first five IITs, faculty played a crucial role lying the foundation aimed at academic excellence and create IIT 'brand'. Most of them were well known and

dedicated academics with global recognition. Each IIT tried to gather best teachers. They laid down a robust roadmap. Initially teaching was paramount to inspire students with strong fundamentals. Gradually research was strengthened. IITs make elaborate efforts much beyond advertisement, shortlisting and interviews to select and induct world class faculty. To teach bright IIT students, teachers must be bright. While a good teacher is a great asset, a bad teacher is a disaster who will ruin students for over 35 years. Therefore IITs are extremely careful in selecting a teacher following elaborate procedures. 'Search, Chase, Hunt' is the strategy. There is a faculty search committee in each department chaired by a professor. They scout around the globe to identify suitable faculty candidates. 'Rolling advertisement' is the norm followed so that candidates can apply any time of the year. When sufficient applications are received search committee will compile the list of suitable candidates, which will be further shortlisted by the professorial committee and sent to the Director for further processing.

These candidates are invited to visit the department at their convenience to give a seminar talk to the faculty and also interact with faculty in that area. Now faculty will form opinion on his or her suitability to the department based on seminar and interaction. This is like bringing a 'bride' to the family. Seminar is a very effective tool to know the candidate's strength on teaching, research, outreach, communication skills, knowledge of fundamentals, relevance of his research and personality. Host faculty may know how well the candidate will gel with the department. Individual feedback on the candidate will be conveyed to the Director in confidence. After collecting sufficient candidates a selection committee meeting will be called chaired by the Director. At least one such meeting per year for a department is common. Each candidate is interviewed for nearly an hour. Virtual online interview of foreign candidates is common. Peer reference is another input for selection. I have attended several IIT selection committee meetings and glad to note that all Directors are keen to get only the best faculty. Meritocracy and ethics are key factors and outside influence is unheard of. Thus IIT faculty selection is a tough and involved process to ensure only top quality persons are chosen. Some Directors especially from new IITs make special effort to ensure that selected candidates join them. Some went an extra mile to even convince their spouse. Some Directors have visited abroad to identify and hunt good faculty candidates. I was in a team led by IIT Ropar Director in 2016 to visit UK, Canada and USA for faculty search and even conducted interviews there. Thus we see that IITs follow out of box methods to get good faculty, which are not followed in NITs. Sometimes we hear criticism of these unconventional methods quoting some rules. Retrograde rules should not shackle IITs by curtailing their freedom to select the best. It is imperative for the government to protect this flexibility which has stood the test of times. As a result of all these efforts we see that most of the IIT Faculty are PhDs from IITs, IISc and reputed foreign universities with outstanding academic records, many are toppers throughout. Flexibility of cadre which does not limit number of positions in each cadre is the best practice followed in IITs (now extended to NITs) that ensures good career growth for good performers. This system should never be disturbed by Govt as this is the international practice.

Selection process for NIT Faculty is not as rigorous and detailed as IITs. While most of the NIT teachers are good a few less meritorious might sneak in. For good candidates with passion for Engineering teaching NITs are preferred destinations next to IITs. But NITs have to evolve suitable selection process similar to IITs to catch high quality teachers from the market. Considerable reform is needed in this front. Present method is very traditional with no novelty. Since most of their Directors are drawn from NITs, they are comfortable with old methods (followed from REC days) and unwilling to change. A few progressive Directors may not venture change for fear of opposition from vested interests and tend to follow beaten track. Since salary structure, academic/campus ambience, and career growth of NITs are now similar to IITs there is no reason why they cannot attract equally competent teachers. A major breakthrough in selection process is need of the

hour and Govt/NIT council must facilitate the same by providing flexibility similar to IITs. Flexible cadre system now extended to NITs should attract good faculty. Good IIT practices like rolling advertisement, search committee and seminar can be easily introduced. Having sat through selection committees of NITs I can vouch that they are quality conscious and select only the deserving. There may be cases of outside elements influencing selection (a legacy of RECs) but is getting rare. A major bane in NITs is the court cases filed by disgruntled elements on selection, some are 'quota' related, a practice more prevalent in RECs earlier. One REC did not have faculty selections for over a decade due to court cases. Stalling selection by the court adversely affect academic activities and teaching. Due to acute shortage of faculty caused by several factors including sluggish selection process NITs resort to hiring temporary teachers from neighborhood who are of low quality and unpopular with students. This is a very retrograde step never followed in IITs and must be stopped. NITs can have good teachers from other Institutes as adjunct faculty to teach on visiting or online basis or follow IIT practices to tackle such problems. Based on my NIT Surathkal experience, I found most of the faculty competent, motivated for good teaching and enthusiastic though research was not their forte. They cooperated with me in institute building. They have the potential to take the institute to higher levels of performance towards IIT benchmark. I found some outstanding teachers, present and past, admired by alumni.

IITs follow some distinct unwritten philosophy which others may not be aware of. Faculty is made to feel that they own the IIT and they are the masters and not the servants. Nobody tells them what to do - they have to create work for themselves and show their achievement. It is not a top-down approach but a bottom-up one. Normally all specialization in a department is advertised so that the bright one with any specialization can be chosen even though it is low in priority. This golden rule must prevail. Even though there is dire need for a faculty in a specialization, person with lower merit will not be chosen in that area. While a bright faculty in any area will create novel activities an incompetent one even in a priority area could be a big drag. NITs can also emulate above practice. A promising feature is that large number of NIT faculty today are IIT PhDs- and doing quite well. Since they are exposed to IIT culture they should be encouraged to adopt IIT practices in NITs.

A good teacher is a rare commodity and shortage of quality faculty for IITs/NITs is a ground reality. They must use all possible means to get adequate faculty for teaching and research and Govt. must provide them due flexibility to do so. Apart from methods mentioned earlier visiting, adjunct and foreign faculty too can be hired. Top up lectures for a course from outside experts from Industry, profession and academia delivered in direct or virtual mode will greatly help students. Many departments in North American universities have nearly 50% adjunct or visiting or non-regular faculty. Instead of hiring inferior temporary teachers from neighborhood, NITs can visit nearby IITs and identify good M Tech or PhD students who could be appointed for fixed term on an ad-hoc basis against regular vacancies. A more permanent solution is to create a new cadre of teaching assistants (TAs) who should be bright M Techs from IITs willing to pursue PhDs. This is similar to Associate Lecturers prevalent in past in IITs. These TAs will be better than regular research scholars as they are better paid and should be considered similar to a faculty though they are hired for a fixed term till they finish PhD (typically 3 to 4 years). These TAs should engage tutorials, labs and help the department in lab development and similar support teaching activities while regular faculty will engage lectures. TAs will be very useful to run flipped classrooms, which is a new trend. I tried a unique experiment in NITK by using bright senior students to help in junior classes for labs (with a small remuneration) which was a great success and highly appreciated by students.

Proper plan for career growth for faculty is important to sustain their interest. A faculty time is spent mostly on four major activities- Teaching plus, Research plus, Outreach plus and Administration plus in varying degrees. A senior faculty may spend more time for administration while a junior one on teaching. NITs may be gravitating on teaching while

IITs on research though this unbalance must be rectified. A transparent mechanism must be in place to assess all these activities and incentivize based on performance in a holistic manner. IITs have evolved unwritten norms familiar to faculty who actively contribute to all activities they enjoy. Thus faculty frustration level is low with negligible attrition. NITs did not have specific norms for faculty assessment since inception. A committee chaired by NIT Rourkela Director Sarangi was formed which prepared norms for NIT faculty for different positions. A section of faculty felt them harsh which took them away from comfort zones. A Recruitment Rule formulated by MoE with 'point' system is in place for NITs [10]. It is elaborate giving credit points to all faculty contributions. But its implementation is often sluggish leading to faculty frustration. It is desirable for NITs to have norms similar to IITs to ensure level playing field and sustain faculty spirit.

A serious dilemma faced by IITs/NITs recently is the increased insistence of MoE to fill up reserved faculty positions quickly. Whenever available suitable faculty candidates of this category are always selected in IITs/NITs as there is no dearth of vacancy since reserved faculty positions are rarely full. Unfortunately, it is a ground reality that number of such available candidates is small and the reason is not far to seek. Catchment area to hunt for IIT faculty is the pool of IIT/IISc research scholars apart from foreign PhDs. Many IITs especially the new ones are facing a major faculty crisis due to this factor as open category slots are full and reserved candidates are rare. If we make a survey of such scholars reserved category number is very small. The matter is very sensitive and must be handled very carefully without sacrificing merit. Only our political masters can help to address this issue keeping in mind the IIT Brand and need to sustain excellence. It is refreshing to note that our lawmakers cutting across party lines are deeply committed to excellence and Brand of IITs and surely facilitate induction of quality faculty to IITs/ NITs. They have mandated IITs/NITs to be world class with high Global ranking. World-class faculty thus is a necessity and short listing and selection norms can never be diluted for any category. A viable way-out must be possible so that proper functioning and quality are not affected. Norm of 'affirmative action' followed in USA to give preference to Blacks and women can be emulated here wherein everything else being equal preference is given to reserved candidates. According to clause 4 of the Central Educational Institutions (CEI) Act institutions of excellence, research institutions and institutions of national and strategic importance are exempted from granting caste-based reservation in faculty hiring. At present, eight institutions are listed under the clause. Same exemptions may be given only for faculty positions in IITs and NITs keeping reservations in student admissions and non-teaching positions intact. MoE of Govt. of India (GoI) is seized of this problem and formed an expert panel comprising IIT Directors and GoI Secretaries which in its report submitted in June 2020 [https://www.hindustantimes.com/education/exempt-iits-from-reservation-in-faculty-recruitment-expert-panel/story-cAjhykLMYPappo4bpjPCrO.html] recommended to include IITs among Institutions under the above clause and exempt them from reservations in faculty appointments. Based on this report suitable decision be taken to avoid faculty crisis in IITs/NITs. There is merit in the view that IITs must be inclusive and not exclusive. All campuses reflect this spirit with PAN India presence among students and faculty to make them 'mini-India'. Since IIT/NIT faculty are often called upon to tackle critical National technological issues such as climate change, disaster management, Himalayan eco-crisis, Covid, National security, green energy, Self-Reliant India (*Atma Nirbhar Bharat*), digitization, smart cities, excellence in faculty quality cannot be compromised. As reported nearly 50% of faculty positions in IITs/NITs are vacant and quota issue will aggravate the matter further and affect teaching and research.

Student Faculty Ratio(SFR) is an important quality parameter of an Institution. Table 2 provides data of different world institutions. Table-3 provides similar data for a few top IITs. Top Institutions have low SFR. IIT/NITs must have SFR of less than 10 (preferably 6 to 8) to aspire world class. SFR of even top IITs (Table 3) are not near world levels shown in Table 2. This is a major parameter to be rectified with support from MoE.

*Table 2 : World Ranking, SFR and Faculty strength of Institutions

Univ	QS Rank	Stud. Fac. Ratio	Total Faculty
IIT Delhi	185	11	843
Nat.Taiwan Univ (NTU)	68	10	2939
KAIST, Korea	41	8	1307
Tokyo Inst. of Tech. Japan	56	7	1492
Hong Kong U of S&T	34	8	
U of Malaya Malaysia	65	8	2386
NTU Singapore	12	6	3812
Peking Univ China	18	6	5302
ETH Zurich Switzerland	8	7	2719
Imp. College, London, UK	7	5	
MIT, USA	1	4	3065

*Table 3 : World Ranking, SFR and International Students of top IITs

IIT	Rank (World)	Stud. Fac. Ratio	International Students	Total Faculty
IITD	185	11	100	843
IITB	177	11	116	1015
IITM	255	11	94	884
IITK	277	13	29	551
IITKgp	280	15	27	770
IIT Roorkee	400	17	202	499
IITGuwahati	395	17	42	410
IIT BHU	281-290 (Asian Ranking)	23	7	304
IITGN	301-350 (Asian Ranking)	11	12	155

(* Ref: QS World Ranking 2022)

9. DIRECTOR, THE CEO

Director is the Chief Executive Officer (CEO) of IITs/NITs who can play a crucial role in running and growth of the Institute. A dynamic director can make a big difference. Academic excellence, vision, leadership and integrity are traits expected of a good director. Role of director is extremely critical in formative years and selecting right director at this initial stage is imperative. It was true for first five IITs and same applies to 2G and 3G IITs. If the first five IITs have created a name due credit must go to their first directors. Among new IITs some have shown greater progress than others mainly due to the role and leadership of their directors apart from location related factors. While role of director is critical before an IIT takes off from 'runway', it will be able to carry on its function effectively due to critical mass of faculty often despite the director. At any stage a dynamic director will make a positive impact, but the damage a bad director can make is minimal since the system is robust built up by the faculty. Historically most of the IIT directors had good reputation and earned kudos for their performance and innovative actions. Most left some positive imprint before they left. I have seen eight directors in IITD from Dogra to Shevgaonkar during my career with varying degree of vision, dynamism, innovations and actions. First director Dogra literally built IITD from scratch transforming from agricultural land to a beautiful well laid campus. He would daily go round the campus and ensure that ambience, greenery and structures are perfect. Director Raju would go for his morning walk with a Dictaphone and record works to be done in different location and forward instructions to concerned to act. Thus many IIT Directors were passionate and emotional about their role to make visible imprint during their term using the autonomy granted by the Act. NIT Directors too must exhibit the same zeal. When RECs were converted to NITs in 2003, then HRD Minister Joshi was keen to hire IIT Professors as their first Directors to inject IIT culture from the beginning. A few IIT Professors volunteered to take up this role and I was one of them.

Selection process for Directors is critical to ensure that a true visionary is chosen. From inception it has been the practice to choose IIT Directors from among persons nominated by peers. Lobbying was considered unethical. Ministry was shortlisting a few among those nominated through a process and called them for discussion with a committee chaired by the Minister. I was called for such discussion twice when Dr M M Joshi was the minister. It was a very pleasant experience as the Minister conducted the discussion in a very dignified way befitting the post and background of invitees who were all well-known academics and senior professors of IITs. A get together lunch was arranged after the discussions for the candidates to interact with Minister and committee members. In contrast selections done for Director for new NITs in 2005 by a committee chaired by a Vice Chancellor resembled mass recruitment of any Govt. post devoid of any dignity. As a legal need open advertisements are floated for Director posts apart from inviting nominations. Not many IIT professors opt for Director positions due to their preference for academics. Very few are madly after power or make undue 'effort' to get a position. Even while serving as Directors they engage in academic pursuits to the extent possible and gladly go back to full time academic activities after their term. Thus response to open advertisement may be limited and nominations may become predominant. But situation in NITs is different. Many professors are keen to become Directors and respond to advertisement in greater numbers. Some may make extra 'efforts' to fulfill their goal. But number of NIT Directors nationally known for Academics, innovative institutional building and visionary leadership is relatively small. If NITs have to compete with IITs and reach higher levels of excellence, it is imperative at this stage to search and select best persons as Directors with no compromise on quality. Many candidates responding to advertisements may be keen on power but with little zeal to take Institute to higher levels. Selection criteria and process must be similar for both IITs and NITs. It is not a good practice to have selection for several institutes in one meeting. It is desirable at this stage to attract IIT professors to take up NIT directorship to inject fresh air. Director must earn respect and support of faculty who need to share his vision for the progress of the Institute. Some Directors especially from NITs are not very

successful in earning faculty confidence, though this is not a popularity contest.

Role of a Director is very complex being accountable to Board of Governors (BoG), Finance Committee and Senate needing often to balance between Ministry *Diktat* and contrary views of faculty. Chairman BoG can play a positive role if he/she functions as a benevolent mentor. Chairman being a Government nominee, political factor in the choice may be unavoidable. Normally they are Industry leaders, well-known professionals/ academicians/technocrats or senior govt. functionaries. Since the post is mostly decorative with an advisory role, the person may be active, passive or indifferent. A progressive forward-looking chairman is always an asset. But some may create problem to Director by being overindulgent and micro-manage. Thus, choice of Chairman too becomes crucial.

10. GOVERNANCE

Since IITs and NITs are governed by similar 'Acts of Parliament' theoretically both must have similar governance mechanism. IIT and NIT councils chaired by Minister of Education formulate broad policy guidelines from time to time as per changing needs. Education Secretary(ES) of MoE operates both the systems on behalf of Central govt. Long back there were Educational Advisors(EA) as part of MoE, to advise the govt. regarding these central Institutions. For reasons best known to Govt. these posts were abolished and IITs/NITs are presently steered by career bureaucrats who are often changed causing discontinuity in approach. It is advisable to restore EA posts to get advise from Educational Experts for these Institutions as ES may have many administrative functions. When central govt is facing severe shortage of career bureaucrats such lateral inputs from domain experts is highly desirable. Similarly Govt, must have Health advisors, Defense advisors, finance advisors, agricultural advisors, Industry advisors etc. from domain National Experts.

'3Gs' are essential for a good institution-good students, good faculty and good governance. IITs satisfy all the three. NITs have good students and faculty but governance needs improvement as it has rigid legacy of RECs that had dual control of centre and state. But new NITs should not be bound by this baggage as they start on clean slate and can emulate best of IIT norms which unfortunately may not be happening. Since bulk of the current NIT directors are from NIT system they may be comfortable with status quo and efforts towards governance reform is not evident. NITs have many court cases filed by faculty and staff reflecting their trust deficit with administration, which is not common in IITs. Two separate sections of MoE deal with IITs and NITs which may inject some difference between the two. While this may be an administrative necessity, ideally all Centrally Funded Technical Institutions (CFTIs) must come under a common umbrella within MOE with nearly similar policies, norms, procedure and rules for Chairman BoG / Director selection, Faculty selection/ promotion, student selection (including entrance tests), funding, infrastructure and general governance. With this level playing field they must be mandated to show similar levels of performance, growth and ranking. NITs must be unleashed with greater freedom to bring out their best and show accountability. IITs do not follow rigid hierarchy with a 'top-down' approach as many norms evolve through 'bottom-up' mode. System is often 'horizontal' with considerable democratization and decentralization of administrative and financial powers. NITs have yet to follow such 'liberal' norms, as vertical hierarchy is still dominant. 'Seniority' among faculty is a sacred word in NITs which has least significance in IITs. Administrative positions such as Deans are never given based on seniority in IITs while NIT professors demand positions on seniority. IIT professors do not normally clamor for power as they are happy with academics, but same spirit is less evident in NITs. Not taking a class is considered blasphemy. There is no specific working hour for faculty. In IITs labs are open all the time and weekends and holidays do not make difference. NITs have to inculcate this practice if not done. For NITs to be counted on par with IITs drastic change in governance system should be effected without delay.

For IITs/NITs to be globally comparable e-governance and paperless functioning must be

targeted. Reputed IT companies have produced effective software for management systems for administration, finance, inventory control, student data, teaching-learning, security and myriad of functions tailored for educational campuses.

Democratic process up to grassroots levels for decision making and implementation is a unique feature of IITs involving debates, discussions and feedback. NITs have their own democratic processes at student and administrative levels though they can learn from IIT models. It must be recognized that IITs have demonstrated fair amount of honesty and dedication in its governing system and NITs must follow this golden path.

11. INFRASTRUCTURE

Infrastructure decides the quality and functioning of an Institute. It is like a 'body' with faculty as 'brain'. IITs and NITs with well laid out campuses in vast area have the best possible infrastructure in India to achieve academic excellence. Campus area of IITs varies widely though performance need not be proportionate. On the high end are (area in acres shown in brackets) IITKGP(2100), IIT-BHU*(1300), IITK(1100).[*Shared with other BHU units] and on the low end are IITD(325), IITR(365),IITGN/IIT Jammu(400), IITBH(432);Rest have nearly 500Acres and above. Converted IITs of Roorkee, BHU and ISM have oldest campuses followed by first five IITs that are over 60 years old often needing renovation and retrofitting. Current infrastructure in these campuses is the result of continuous up gradation, additions and modernization as per expansion plans. Eight 2G IITs have modern campuses as they moved in recent years after operating from transit campuses. But these campuses are still in development stage. Five 3G IITs have yet to complete new campuses as they are functioning from transit sites. They have a big challenge ahead. NITs too have a similar story with established campuses for old RECs and new campuses for new NITs in different stage of development. An area of 500 Acres is considered minimum for a good residential campus as much reduced area will be a perpetual handicap for proper functioning and expansion. It is wise to get as large an area as feasible for a new campus. Learning from the experience of old campuses, new ones must take some precautions before and after building their campus. Almost all IITs/NITs face encroachment from neighboring communities. Many campuses have porous boundaries with outsiders regularly trespassing and often creating security risk. Some campuses have perennial problems with neighbors needing to buy peace through negotiations for smooth functioning of the Institute. Sometimes local leaders may flex muscles! Director's tact becomes crucial to diffuse a crisis. Instances are many. IITKGP has a public road in the middle of the campus for outsiders to pass through. IITD has provided gates for neighboring villages to facilitate access for locals into the campus. At NITK I discovered many porous boundaries with regular trespass. I negotiated with all concerned neighbors in a spirit of give and take and regularized the complete campus boundary. A major challenge was the beach bordering the campus (NITK is the only campus in India to have its own beach).

Since it was open outsiders would regularly enter campus space through the beach and vandalize. I got special sanction from MHRD and got a boundary wall constructed bordering the beach so that we re-captured our own space, which is now put to good use. When I was VC of Central University of Karnataka (CUK) we moved to the new campus in Nov.2003 near Kadiganji Village off Kalburgi. Villagers broke open a part of boundary wall for access to their cattle to graze. Many villagers feel they have claim over campuses having ceded their land to build the Institute. They demand some favors such as jobs. Many Institutes accede to their demands as a goodwill gesture and humanitarian considerations. IITD faced a peculiar problem of construction workers not moving out even after construction and forming a slum in the campus. A tactful Director evacuated them only by end of last century. The first step to build a new campus is to physically take possession of the land allotted by the State Govt. only after legally verifying all transfer land documents. The land may belong to government or private farmers or both. A legal expert must ensure that there are no litigations pending. As reasoned above, it is imperative to first

build a strong boundary wall with a security system in place before starting inside construction. Next step is to fix a progressive and experienced Architect to prepare campus building plan as per latest environmental 'Green' standards such as GRIHA (Green Rating for Integrated Habitat Assessment) [11,12] with maximum functionality and without unduly upsetting original landscape such as undulations, hillocks, water bodies, greenery and forests. Then a critical decision is to fix a competent and efficient builder. Most Institutes opt for Govt. agencies such as CPWD, RITES though some private players such as L&T, Gammon India too have built some campuses. Time and Cost overrun are the bane experienced by many Institutes missing targets and derailing academic plans. Effective utilization of project funds without leakages to maximize output through fiscal discipline is highly desirable. -'Good Governance is to effectively and efficiently transform funds and resources to Assets'. This can be a good guideline for all Directors. In initial stages pre-fabricated structures can be installed in transit or regular campus. This experiment has been successful in many new IITs to quicken activities. They are as good as permanent. New NITs should follow this practice if not done.

All IIT/ NIT campuses must have the following components. While new ones must be state of art old ones must update to current needs. There is no reason for NITs to have inferior facility compared to IITs in all aspects of infrastructure. These Campuses must be trendsetters for others with sustainable, green and progressive features.

a) Academic Area: Departments, Centres, Laboratories, Class rooms/ Lecture Halls

b) Centralized facilities: Library, Workshop and Computing Centre.

c) Administrative area: Offices of Director, Registrar, Deans, academic/establishment / estate /engineering (campus maintenance) sections

d) Hostels

e) Guest Houses

f) Auditoria (State of art), Community Halls for Academic, technical, cultural and social events including international conferences.

g) Residential area for Director, Faculty and Staff

h) Hospital

i) Campus School

j) Commercial complex: shopping centres, Banks/ATM, Post office

k) Sports Complex

l) Visiting Professor (Furnished) Flats.

m) An improved Hostel comprising small one room flats (with attached kitchen) for Project staff, married research scholars and international students.

n) 24x7 services for Electricity, Water and Communication (internet)

o) Efficient in-campus transport

Lecture Halls must be state of art with latest presentation facilities and teaching software both for in house and distance mode. Classrooms too must be modern to cater to lectures, tutorials and 'flipped class room'. Laboratories must be specific for teaching and research. Teaching laboratories both in IITs and NITs are generally weak and uninspiring to students. Many of them are outdated not in tune with latest trends. Very few teachers take interest to set up good teaching laboratories. They must be truly modern with latest equipment, instrumentation, data acquisition and data processing arrangement. Sensor based virtual instrumentation can make experiments interesting to students. Each Institute must have a suitable Educational Technology centre for use by Faculty and students both for in-house and outreach teaching-learning activities. Students can have expert lectures from other institutes which can be leveraged by local teachers.

Concept of Library has undergone a sea change with digital library, e-books and e-journals in vogue. Students get almost infinite information online. Proper reorientation with inputs from library & information science experts may be required for a new centralized or decentralized library. It may

need many computer terminals. Need for computer centre at Institute or department level need to be debated as all students will now have laptops with all pervasive internet facility. Suitable computing facility may be provided to all stakeholders as per needs. Institutes must have updated licensed software for engineering and other functions. This is often a tricky issue as vendors continuously update software and fleece users. Workshops must have good fabrication facilities for students to make prototypes and models to try their innovative ideas. This may often be expensive and outsourcing may be an option for projects.

With digitization, online and mobile banking functions of Banks are drastically reduced and leading ones discourage customers to visit their Banks in person. Campus Bank must be in tune with this need. With Internet communication and email Post Office too has minimal role and must be planned to this changing need.

Campus must be totally Internet and WiFi enabled for offices, residences and students with latest and upgradable systems. This will considerably enhance working efficiency and link to external world. For a 'green' and sustainable campus energy management, water management and waste management are critical combined with GRIHA norms[11]. Each new campus of both IIT and NIT can be truly innovative and sky is the limit. Old Institutes too must upgrade to become green. Though grid electricity is available to all campuses, its reliability and adequacy is a problem. Standby diesel based units are installed for essential needs though they add to pollution. With advances in renewable energy technologies, locally available sources such as Solar, wind and Bio energy can be exploited to augment energy need. A micro-grid combining utility supply, diesel, solar, wind and Bio energy is now a technically viable solution employing smart-grid concepts and energy balancers to save grid electricity. IITs and NITs being technology leaders must steer this idea and demonstrate. Similarly water management for new campuses must involve rainwater harvesting, sewage treatment plants and recycling to reduce dependence on external water supply. Above solutions will be local specific based on resources and needs. Energy management too has varied solutions as per campus conditions. Biodegradable wet waste generated by local greenery and community can be converted to heat, electricity and manure through proper process and should not be sent out of the campus. Food waste is a major bane by students and must be discouraged. IIM Bengaluru has an effective way for guest houses and hostels and IITs/NITs may emulate. Dry wastes like paper/plastic generated by students, faculty and offices too can be re-processed or recycled. IITs/NITs produce huge E-waste and disposable hard ware equipment and instruments, which are getting obsolete fast. Elaborate stores procedures delay their disposal causing huge junk occupying over 30% of usable space. A mechanism to dispose them in a green and effective manner through reuse and recycling of components must be evolved and implemented. IITs/NITs must show the way to others in this regard. Since area of all campuses is large and scattered there must be effective local transport facility. Students must be mandated to use only bicycles (or e-bikes) and Faculty and staff will have their private vehicles. Presently available Electric vehicles (minibuses) should be employed for in campus mobility as role model for others.

Student Hostels in IITs and NITs must be models with good infrastructure and ambience as they can build their personality through community living. Some IIT students feel that they learn more in the Hostels than classrooms. While classrooms impart domain skills hostels may provide living skills with proper planning and effort by the Institute. We must ensure that students are happy and healthy in the hostels with proper housekeeping and cleanliness. Rooms must be livable and toilets and bathrooms must be useable. But they must have modest and simple living with no luxuries and scope to exhibit their wealth. They must have egalitarian inclusive living with no scope for discrimination based on caste, region and religion. Many campuses in India have seen disturbance and violence due to bad ambience and we can be proud that IITs and NITs are exceptions. In general all IITs resemble 'Mini-India' with 'melting pot' of students and faculty from all parts of the country, which is a great asset. While one student per room may be

ideal many institutes are constrained by resources, space and student number often needing to house more per room. Multistoried hostels with lift facility may be inevitable due to large student strength and reduced land area. All Hostels must have a common room, indoor game facility including TT, Yoga Room, Gym., small outdoor game facility (Badminton, Volley ball) and suitable facilities for recreational, creative and cultural activities for inmates. A good open quadrangle for assembly is a necessity. Since all will have laptops, common computer room has become redundant but an excellent Wi-Fi facility is a must in all hostels. Students must get good healthy food in Hostels. Self managed or outsourced mess can be planned considering quality and expenses. Students being ultimate stakeholders must have a say in managing the mess arrangement since quality of food cannot be compromised. Suitable canteen in academic and hostel area is needed for food needs of students, faculty and staff beyond hostels. Centralized Natural Holistic food outlet is highly desirable for students and staff to get healthy (and not junk) food. IITD has one such outlet by a suitable vendor and successfully run. Other IITs/NITs too may emulate if not having one.

Warden is the officiating head of a hostel who normally operates under Dean of Students. A good warden can make positive impact to students though the scope may be limited. Caretaking, housekeeping and messing staff play a crucial role to make students' life comfortable. Some of them are very dedicated and love the students as their own children. Inmates too reciprocate this feeling. It is desirable to take good care of this staff with incentives and rewards as they are from poorer sections. Some Institutes have novel schemes for them including educating their children. Addiction to bad habits is a bane among a section of youth and it is imperative to insulate students from this menace in the Hostels. Smoking and alcohol consumption are generally prohibited in Hostel premises though strict enforcement is the key. Dangerous 'drug' menace which is a crime too must be strictly dealt with including proper treatment to the addicts. Ragging is another nuisance in hostels at the beginning of academic year that need considerable effort to curb. Though declared illegal it is puzzling that some students and faculty consider it a necessary evil to bring freshers and seniors together.

Campus Hospital is central for Healthcare of the community though it can only play a limited role. Most Institutes are linked to specialist Hospitals in neighborhood for special treatment. Emphasis must be on healthy living with steps to escape from disease 'Wellness' must be preferred to illness. Students must be encouraged to practice sports, exercise, yoga and Naturopathy which have become global trends. Facility for non-formal treatment like Ayurveda and Homeopathy too can be provided as done in some Institutes and encouraged by the govt. Holistic Health must be the goal. Health challenges increase with ageing of Faculty and staff (serving and retired) incurring heavy expenses. Health Insurance schemes can be handy. Group Insurance is in place in many IITs/ NITs. With escalating hospital expenses this too is often insufficient causing heavy financial burden to the concerned. This is a serious humanitarian issue. Best solution is to have a combined group insurance for all IITs together with minimum premium. Same model can be followed for all NITs together. Ministry must step in to provide logistics and help.

Good Campus School is needed for quality education of children of Faculty and staff. In most campuses Kendriya Vidyalaya (KV) schools are established as they have good National standing. Some campuses have other schools too catering to local boards. With brand private schools coming up in neighborhoods many parents are opting for these schools due to their name and fame paying heavy fees with KVs underused. At IITD almost no faculty send their kids to local KV. Same is true for bulk of support staff with local KV used mostly by Class-IV staff and central govt. employees on transfer. With lowest strata of society using this school quality of students too is skewed as they come from disadvantaged sections with minimal parental guidance. Thus teachers too get demotivated compromising the teaching quality. Consequently KVs in IIT/NIT campuses tend to be of a lower quality compared to other KVs outside.

This is a peculiar situation with no solution in sight due to little patronage from faculty for whom campus school does not matter. Sadly, this reflects a social class cleavage in our society. Despite these drawbacks efforts must be made to make Campus schools of IITs/NITs among the best in the country through proactive steps from concerned institutes using high intellectual and technical potential.

Sec.10.8 of NEP mandates to increase the Gross Enrolment Ratio (GER) in higher education including vocational education from 26.3% (2018) to 50% by 2035 with a minimum of 3000 student in each HEI cluster. Thus, Each IIT/NIT campus must plan infrastructure for a minimum student intake of 5000 with 50% UG.

12. LOCATION AND CONNECTIVITY

Location of an Institute has an important bearing on its quality, progress, development and perception. Proper connectivity of campus through Road, Rail and Air has become a necessary condition. Location near a National/State highway and prime railway station on a National trunk route (connecting major cities) would be plus points. Due to massive expansion of National 'Air' network with affordable fares, ideally each campus must be accessible within two-hour drive from the nearest Airport. Location near an international airport is a bonus. Chosen by political and non-academic considerations some institutions are facing locational disadvantages. Facilities in the city as regards, schooling, healthcare, marketing, industrial infrastructure will add to attractions. Aspiring faculty naturally scout for best possible city/location to join. Since most of the faculty spouses too are well-educated opportunities for their employment and professional growth in that place are becoming major factors in attracting good and motivated faculty. Due to above considerations, in general, IITs are better located compared to NITs. Thus Major Metros Delhi, Bombay (Mumbai) and Madras(Chennai) have become the most preferred places for both faculty and students. Among the first five, Kanpur and Kharagpur are now facing connectivity issues due to their distance from Airport. Mandi, Dhanbad and Bhilai too have similar drawbacks. Most of the IITs are in or near state capitals or their major cities that are normally well connected by Rail and Air. A few NITs have good Air connectivity while many have connectivity drawbacks being located in hinterland such as Warangal, Andhra, Hamirpur, Rourkela, Durgapur, Jamshedpur, Kurukshetra, Puducherry, Uttarakhand and a few in North-East though some have good Rail connection. Attracting good faculty to these NITs is hard unless they have some niche USP.

13. TEACHING, RESEARCH AND OUTREACH

As mentioned earlier an IIT Faculty is engaged in Teaching, research and outreach activity. It is pertinent to ponder the performance of NITs vis-à-vis IITs in these activities.

In reality there are 'good' teachers and 'not so good' teachers in both though IITs have relatively more competent teachers. Many IIT teachers tend to introduce innovation in teaching. Syllabus of a course is just a guideline in IITs as different teachers may teach the same differently. Question papers are generally challenging to test fundamentals rather than facts and do not follow the university format of 'explain and 'describe'. Surprise and open book tests are common. Open ended mini-projects, term papers and self studies are prescribed in many courses that form part of assessment. Technology assisted learning is encouraged. Since they are actively engaged in research, sponsored projects and consultancy the experience is often shared in the class. NITs in general follow traditional method of teaching due to REC background. NIT teachers must be encouraged to elevate the teaching methodology similar to IITs. Good teachers based on student feedback and peer assessment must be rewarded.

Research in IITs tends to be far ahead of NITs based on publications, theses guidance, sponsored projects and consultancy. This gap must be bridged through sustained efforts and funding.

Outreach activities are varied and depend on individual faculty interests, capacity and efforts. Continuing Education Programs (CEP) to train working professionals and teachers are regularly conducted by both IITs and NITs perhaps to a similar

measure. Faculty of both is engaged in Professional Society activities by being office bearers, organizing technical events, conducting student competitions and establish student chapters. This will enlarge the horizon of students. They deliver invited lectures to outside bodies though IIT faculty has more invitations. They are represented as experts in several outside bodies of academia, industry and government with specific functions though IIT faculty participation is higher.

14. AUTONOMY, REGULATION, ACCOUNTABILITY

Autonomy is a prime factor for IITs to reach global fame. There is a feeling among faculty, alumni and administrators that this autonomy is slowly getting eroded with subtle govt. control. The fact that IITs are still moving ahead despite minor hick ups reflects their strength and zeal. It should be recognized that govt. is also providing several positive inputs and supports over time to achieve excellence. Declaring a few as centres of eminence is one such recent move. Autonomy and regulation are contradictory, as those with greater autonomy will have fewer regulations or controls. But Autonomy is linked to accountability and responsibility. An Institution should earn autonomy through good performance as exhibited by IITs. Since IITs and NITs are centrally funded visible or invisible controls may be inevitable. Autonomy has three main facets namely academic, financial and administrative. Senate, Finance Committee and Board of Governors (BoG) are respectively supreme in these matters as per Acts/Statutes and Ministry theoretically has little role in these matters to micro-manage. IITs have total academic academy though govt. regulates on norms for student and faculty selections. Thus IITs have developed many novel academic programs and reorganized departments, centres and schools resulting in their steady growth. Financial autonomy is relatively restrictive as bulk of funds comes from central govt. and regulated by finance committee with govt. representative. Director has enough powers to internally allocate funds under plan and non-plan heads. There is considerable decentralization of financial powers within the system down to departmental heads, IITs are free to generate additional funds through sponsored projects, consultancy and donations. Corpus fund too can be established for a rainy day. Situation tends to be dynamic as govt. comes up with different financing systems over time. Administrative autonomy is still fuzzy with several norms laid down by govt. Still IITs enjoy reasonable internal autonomy to administer. NITs do not appear to enjoy similar autonomy as IITs though they deserve the same. Accustomed to archaic REC norms they have to gradually unshackle themselves and enjoy fruits of autonomy that should translate to improved performance. NITs seem to enjoy good academic and financial autonomy while administrative autonomy needs improvement by reducing bureaucratic controls. In NITs Registrar and Deputy Registrars tend to have more powers compared to Deans unlike IITs.

On this topic it is worthwhile looking at how autonomy works in leading foreign universities. During my couple of stints in Canada as a visiting Professor I discussed this matter with local academics. Most of the Canadian Universities are govt. funded shared between Federal and Provincial Governments. Apart from providing grants they do not interfere in normal working of the university nor micromanage. But universities are highly accountable through good performance on which funding is based. State funding is mostly for teaching expenses and infrastructure. Professors are always on their toes to get external funding for their research and perpetually preparing proposals. They have total financial autonomy to use these funds, as they are accountable to funding agency to meet objectives of the project. Thus universities have total freedom but strictly watched for performance. Such a culture must seep into IITs and NITs with effective autonomy to perform and excel. NEP lays great stress on autonomy down to faculty level (Sec.10). This spirit must be reflected in IIT/NIT though they are far ahead of other HEIs.

15. ACCREDITATION

Accreditation is a major quality control mechanism for Higher Education in India. National Board of Accreditation (NBA) set up by MoE is playing an effective role in accrediting Engineering

Institutions including NITs though IITs are outside its purview and exempt from any accreditation process. Though this exemption is resented by others, IITs have demonstrated their prime position through research output and rankings. Core philosophy of NBA is outcome-based education aligned to the Washington Accord to which India is a signatory. NBA became administratively and financially autonomous in 2013. It has different norms for Tier I and Tier II institutions and NITs belong to former. There are Program and Institute level criteria.[www.nbaind.org] Most of the NITs have NBA accreditation as all have done reasonably well to meet NBA norms. But such accreditation is more to do with satisfying norms than gaging excellence. It is desirable that the NBA experts for accreditation of NITs be drawn from IITs and IISc who can assess and guide the Institute based on their wide exposure and experience. Should IITs not be subjected to some form of accreditation? After all there may still be under-performing departments, centres, units and individuals though their number may be less compared to NITs. It is desirable to have regular monitoring of departments and faculty though some internal assessment system exists in most IITs. The data may be made transparent and public. We may follow a scheme practiced in MIT (USA), wherein a high power "Visiting Committee" comprising reputed academicians, industrialists, alumni, researchers, corporate leaders visits the Institute for a specific period, make thorough study of performance of all units and submits a report at the highest level. This report can be like a 'Bible' for the Institute to take follow-up actions and frame policies. Though IITs had review committees (latest one was Ramarao Committee formed decades ago) their effectiveness is marginal as they are highly aperiodic. Thus the 'Visiting Committee' scheme can be an indirect way to accredit IITs.

16. CONCLUSION

IITs and NITs totaling 54 are rated as top-quality technical institutions in India with very good inputs in terms of students, faculty, funding and infrastructure. This is the largest group of state supported institutions in the world that has potential to make global impact and to propel India to technical leadership. While their National standing is recognized they are facing criticism for not being in top world ranking. This article examines their Strength, Weakness, Opportunities and Threats and suggests actions to take them towards top global levels. Steps to bridge the gap between the two are detailed. Historical evolution of IIT and NIT system are presented. Student admission to B.Tech programs needs a thorough relook**.** One Nation, one entrance test is ideal for the country for Engineering admissions to all Institutions similar to NEET for Medical entrance. JEE (mains) must be the sole exam for the same with inbuilt difficulty levels to choose the best from the rest. JEE (adv) must be scrapped to reduce need for coaching. As expected, old 5 IITs are the top preference of successful JEE candidates followed by converted and a few 2G IITs. Other 2G and 3G IITs will share the rest. NITs at Trichy, Surathkal, Rourkela and Warangal attract top JEE(main) rankers on PAN-India basis. Effort from other NITs to attract JEE toppers is not visible. Many candidates have to compromise between institution and branch and often land in a combination not necessarily their best choice.

Though most candidates prefer IITs to NITs, there is no information on candidates sacrificing an IIT for an NIT based on reputation of NIT or getting a preferred branch due to differing basis of selection. Thus, a common entrance test as basis for final selection in both IITs & NITs will project proper perspective to compare institutions and branches. This would motivate all 54 institutions to attract best students and create healthy competition. All IITs and NITs must be provided 'level playing field' to exploit the full potential of each institution. With identical inputs each institution must be mandated to show identical perceptible output with progress and growth. Factors for equal treatment include governance system, admission process, entrance tests, faculty selection, career growth, funding, salary structure, student-teacher ratio, global access, campus infrastructure, Director selection and autonomy. This step is necessary for NITs to catch up with IITs. Students are major stakeholders and IITs followed by NITs attract the best through

JEE. Reservations have made classes heterogeneous due to varied JEE ranks. With over 10 lakh aspirants appearing for JEE for admissions many equally bright students are left out who land up in other less reputed institutions due to limited IIT/NIT seats. Many motivated among them keen on top quality engineering education go abroad supported by self-finance or bank loans mostly with a 'one-way ticket'! Allowing foreign universities to set up campuses in India may help them and the country will prevent both fund and brain drain as suggested by NEP. IITs get good Masters' students through GATE who are toppers from other colleges though NITs do not attract similar quality. Doctoral students of IITs are of mixed quality, some motivated and some pursuing for specific compulsions. There is need to increase sponsored candidates from academia and industry who generally fare well. NITs generally do not attract good quality regular PhD students. Faculty form pillars of an Institute.

IITs make elaborate efforts to select and nurture best faculty. Similar efforts are not apparent in NITs though they attempt to select the best among aspirants. NITs must emulate IIT practices for faculty selection. Flexibility of IITs to hire faculty must be pursued and further liberalized. No policy must be thrust on these institutions to dilute quality of faculty and teaching, as a bad faculty will harm generations of students. In view of chronic faculty shortages, liberal policies must be in place to hire adjunct and visiting faculty from across the globe from academia and industry as practiced internationally. Practice of hiring ad-hoc faculty in NITs must be stopped. Effective use of postgraduates in teaching as TAs must be encouraged. Faculty career growth schemes must be same for IITs and NITs for identical competence and performance. Flexible faculty cadre scheme of IITs now extended to NITs is necessary and must continue. Director being CEO must be a visionary with leadership qualities, academic excellence and integrity whose choice must be purely on merit and competence ignoring 'pulls'. Most of the IIT Directors have played a pivotal role in bringing them to current quality status as healthy and mature norms through nominations were followed in their selection though advertisement was a legal necessity. Norms and procedures to choose NIT Directors must be identical. Since NITs currently need greater push only the best be selected as Directors preferably from IIT system. A high-power search committee must be formed for each IIT/NIT to search and recommend best Directors. IITs have a fairly progressive and dynamic governance mechanism, which NITs have yet to catch up due to history though both are governed by similar, acts of parliament. Non-hierarchical decentralized administration is a strength of IITs that need to be emulated by NITs. Governance structure is same for both with respective councils chaired by minister on top followed by BoG, Directors, Deans and Heads of departments as per statutes.

NITs need considerable governance reform by unburdening baggage of RECs. Both IITs and NITs must come under the same administrative umbrella within MoE to formulate identical norms. All IITs and NITs have reasonably good infrastructure having areas of 500 acres and above. Old institutions that are more than half century old need modernization, and retrofitting though they are continuously updated as per needs. 24x7 water, electricity, internet and communication must be ensured in all and make them 'Green' campuses with GRIHA norms. Sustainable water management, energy management and waste management must be implemented to be model to the community and neighborhood. Location / Connectivity is an important factor for an institute to attract best faculty and students, which in turn decides academic performance, rating and international linkages. IITs are better located compared to NITs with most of them near an Airport with good rail and road connectivity as they are in major cities and state capitals. Many NITs are in big cities with airports while a few are remotely located especially in northeast. Institutions with location handicaps must get added inputs and incentives. Teaching is a prime activity in IITs& NITs and there are good, motivated and inspiring teachers in both though many IIT teachers innovate in teaching with modern methods and tools. NIT teaching and testing tend to be traditional and need major reforms. Video lectures of IIT teachers are popular. In Research IITs are quite ahead of NITs, which need major boost.

Though IIT research is below global levels as reflected in rankings, publications and sponsored funding are increasing with a few industries setting up domain specific research centres in IITs. A major bottleneck is research funding which is far below those of developed world. Autonomy- academic, financial and administrative- has a major bearing on the performance of an Institution. IITs have enjoyed autonomy in varying degrees which is the prime reason for their fame. It is essential not to weaken this autonomy though some govt. control and regulation is inevitable being state funded. NITs too must have the same level of autonomy. They must earn the autonomy with proper accountability through regular quantifiable improvement of performance. NITs are subjected to NBA accreditation to which IITs are exempted, a policy questioned by some. It is ideal to have same norms for both. 'Visiting Committee' scheme as followed in MIT (USA) may be tried for both.

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ATMNIRBHAR BHARAT : EASE OF DOING BUSINESS

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ABSTRACT

On 12th May 2020, the Hon'ble Prime Minister unveiled Atmanirbhar Bharat Abhiyan, a revamped version of the "Made in India" initiative. Finance Minister Nirmala Sitaaraman announced a comprehensive aid plan to help countries cope with the COVID-19 epidemic within five days. She emphasized that the initiative's stated goal is not to engage in protectionism against other nations. Foreign direct investment (FDI) and foreign technology are always welcome in areas that need them. India proved its self-sufficiency in the face of a global pandemic by increasing production of personal protective equipment (PPE) from zero at the start of May to 1,50,000 pieces per day by the end of the month. In this article, we analyze which economic and social fields show promise for future self-sufficiency. It looks at the barriers to becoming a worldwide supplier and offers several ideas for overcoming them. On 12th May 2020, the Hon'ble Prime Minister unveiled Atmanirbhar Bharat Abhiyan, a revamped version of Made in India. Finance Minister Nirmala Sitaaraman announced a comprehensive five-day rescue plan to help countries cope with the COVID-19 epidemic. She stressed that the initiative is not intended as a form of protectionism towards other nations. The use of foreign direct investment and technology is always appreciated in such fields. By increasing production of personal protective equipment (PPE) from zero at the start of May to 1,50,000 pieces per day by the end of the month, India demonstrated its capacity for self-sufficiency in the face of a critical pandemic situation that prevented international movements of goods and services. The study zeroes in on industries and fields with long-term potential for self-sufficiency. It examines potential roadblocks and offers a variety of recommendations for maximizing current resources in order to become a worldwide supplier.

Keywords: *Atmanirbhar Bharat Abhiyan, Pandemic, Ease, Business, Startups*

1. INTRODUCTION

Positive changes in policy, internal capabilities, and digital revolution are propelling India toward 'Atmanirbhar Bharat. The country's ambition to achieve industrial independence is a primary factor in its increased exports, influx of foreign direct investment, and international partnerships. India has emerged as a top investment destination as a result of its relaxed compliance regulations, targeted policies, widespread digitization of processes, and plenty of investment opportunities in developing industries. India's standing as a center for starting new firms is being bolstered by a number of government initiatives.

The manufacturing sector continues to get considerable attention, and international cooperation is anticipated to be driven by India's

cost advantage and location advantages. For expansion in several markets, including those related to technology, healthcare, financial technology, and education. There has been development in a number of promising emergent industries, and the government has been working to make it easier for businesses to thrive. Such examples include the Production Linked Incentive (PLI) program, which helps to increase domestic manufacturing, and the PM Gati Shakti Plan, which helps to integrate planning and simplify projects. Policymakers have loosened restrictions on foreign direct investment (FDI) in a number of areas, either by raising the ceiling on FDI in such areas or by including them in the automatic route. Ease of doing business is also supported by customs regulations including lower taxes, surcharges, and tariffs.

With an eye toward equitable development, the Indian economy is laying the groundwork for increased economic activity. The trend of international corporations and investors entering the market to take advantage of rising sector potential is encouraging for local enterprises as well. So, it would be essential to take advantage of the socioeconomic benefits, technological development, and governmental backing to achieve increased profits and successful commercial results. Reforms to make it easier to start and run a company in India have been pushed by both the federal and state governments in the aftermath of Covid-19.

The country's ranking in the World Bank's Doing Business report improved from 142 to 63 as a result of these efforts. The Finance Ministry of India has proposed a number of changes aimed at making it easier to conduct business in India, collectively referred to as the Atmanirbhar Bharat package. This reform momentum must be maintained with consistent monitoring in order to further improve the competitiveness of Indian business. Short-term actions and long-term plans must be taken by both the federal and state governments if the changes are to have an impact at the industry's ground level.

2. ROLE OF STAKEHOLDERS & ECOSYSTEM AND EMERGENCE OF START-UPS

Successful entrepreneurs innovate, bring new products and concepts to market, improve market efficiency, build wealth, create jobs, and ultimately boost economic growth. De novo firms that unleash creative destruction shift surpluses from rent-seeking large producers to consumers and broader society. Policymakers have prioritized economic objectives such making it simple for businesses to operate in their jurisdictions, encouraging investment from outside, boosting exports and reducing imports, creating new jobs, training workers, and fostering an entrepreneurial spirit.

While discussing startups, it's important to note that the entrepreneurial ecosystem is regulated by a number of different stakeholders, and that these stakeholders and individuals interact with one another, playing various roles depending on the stage of the startup. Culture, talent, infrastructure, global mindset, regulations, capital, knowledge, rebellion, market, communication skills, and so on all contribute to a thriving entrepreneurial system, and their strategic application helps any economy's Startups Ecosystem flourish. Government, state startup missions, public sectors, private corporations and other businesses, the academic and research community, venture capitalists, and the startup community itself are all important players in the startup ecosystem. The importance of these actors in India's startup scene and the country's growing trend toward self-sufficiency.

For the Indian economy, the Prime Minister's "Invest India" program has been a watershed moment. It has allowed India's brightest minds to dream big, take action, and create transformative businesses that are revolutionizing and speeding up the country's startup scene. The strategy is supplemented by changes outlined in India's annual budgets from 2014-15 through 2021-22, as well as efforts by the Department of Public Instruction and Information Technology (DPIIT) and state startup missions. It paved the way for new opportunities

on many fronts for startups and SMEs, providing essential support for the nascent Startup ecosystem. The National Innovation and Startup Policy, the Atal Innovation Mission (ATM) to promote R&D through industry-academia partnerships, the Skill India Mission, the Seed Fund Scheme, and similar programs and schemes with ease of doing business measures are all included.

As a result, startups in India across industries have improved customer service by expanding their digital infrastructure to even the most remote parts of the nation via the use of Work from Home (WFH) policies. The ecosystem in the digital sector has been shifting as a result of technology-driven solutions like the UPI interface, and there are ongoing initiatives to improve the underlying digital infrastructure. This has resulted in the proliferation of startups in fields as diverse as financial technology, educational technology, agricultural technology, health information technology, logistics information technology, etc., all of which have generated enormous value for their users by simplifying and speeding up a variety of processes and providing greater openness and accountability.

3. SIMPLIFYING THE BUSINESS ECOSYSTEM IN INDIA

Regulatory changes are primarily motivated by the World Bank's Ease of Doing Business Programme. It rates the ease with which businesses may start up and operate in 190 different countries across 10 different metrics. Establishing a business, registering property, obtaining building permits, obtaining electricity, obtaining credit, paying taxes, trading internationally, safeguarding minority investors, enforcing contracts, and handling insolvency are all factors to consider.

4. NEED OF MAKE IN INDIA AND AATMANIRBHAR BHARAT

India joined the ranks of the "Fragile Five" in 2013 as its growth rate dropped to its lowest level in a decade. In 2013, Morgan Stanley invented the phrase to call attention to countries that have grown to rely too much on volatile foreign investment to fund their development. Turkey, Brazil, India, South Africa, and Indonesia made up the Fragile Five.

Further issues with India's manufacturing industry were its slow growth (as a percentage of GDP), inefficient working method, and underdeveloped R&D foundation. The right strategy was required to make India a global manufacturing centre, increase GDP growth, generate jobs, and entice FDI. The Make in India Mission was established to address these issues head-on and promote the growth of India's manufacturing industry. The create in India initiative, which aims to make the country a center for innovation in design and production, was developed in response to a pressing need. India's growth rate dropped to its lowest level in a decade by 2013, when the much-hyped emerging markets bubble broke. The goals of the Made in India initiative were to create more jobs, reduce the country's reliance on imports, and make it easier for businesses to set up shop in India. Since the complete liberalization of FDI in India, the Make in India initiative has helped to create a more advanced and efficient infrastructure and to welcome investment from elsewhere.

In 2020, the globe faced significant difficulties due to the spread of the COVID-19 pandemic, which had a particularly negative effect on global economy. The global economy experiences massive inflation and a depression as a result of the epidemic. The decline in foreign commerce that India faced as a result of the COVID-19 epidemic sparked the concept for the country to become self-sufficient in certain areas and a worldwide supplier. The new idea of an independent India emerged during COVID-19. The fundamental idea behind "Aatmanirbhar Bharat" was to increase domestic production of previously imported goods in order to meet domestic demand and expand the country's export market. An expansion of "made in India," Aatmanirbhar Bharat The primary goal of the Government of India's "self-reliant India" initiative is to transform India into a leading global manufacturer and ensure the country's continued access to essential products and services. On 12 May 2020, Indian Prime Minister Shri Narendra Damodar Das Modi proposed a $20 trillion economic rescue plan to stimulate different economic sectors and combat the epidemic. A new initiative called "Aatmanirbhar Bharat" has been launched to help India become

more self-sufficient. The government hopes that everyone from cottage companies to MSMEs to day laborers to street vendors to the middle class to large corporations would benefit from this package.

5. METHODOLOGY

Case cases from the Indian setting are used for descriptive analysis and discussion in the paper. Based on the most recent policy announcements and their impact on the ground, the research employs a multidisciplinary content analysis to draw its conclusions. This study is also empirical since it draws on the authors' first-hand knowledge of Atmanirbhar and how it relates to official government policy. The data for the research comes from a variety of secondary sources, the majority of which are online databases including Elsevier, Google, and Google Scholar as well as reputable newspapers. Articles from digital newspapers and magazines, scholarly works, and press releases from government agencies are all examples of the types of publications cited. The data serves mostly as back-up for the study's discussion and as a basis for drawing conclusions. The literature assessment highlighted the significance of the present epidemic and suggested ways in which India may fend for itself economically.

6. DATA ANALYSIS

Each year, the World Bank ranks 190 nations based on how easy it is for their businesses to operate in that country. Using a set of 10 criteria, we rate each nation and then use that score to determine where they fall in the overall rankings. Table 1 displays the World Bank's rankings for how easy it is to start a company there.

India's goal is to get into the top 50, but how close are we currently? India's current rating of 63 for 2020 is a flawless score, placing it in the "Easy" to conduct Business category, which comes as a pleasant surprise given the country's reputation. Yet, the devil is in the details, as the old adage goes. Do you think it's as simple to conduct business in the United States as the rankings suggest? This is not a simple question to answer. To accomplish so, it is necessary to analyze the component indexes to learn about India's strengths and weaknesses. This will allow us to determine what steps India must take to advance in the rankings. If this is complete, we can go on to the next stage, which is making recommendations for how to improve our performance in these areas. Table 3 displays the status of the Indian economy in 2018 and 2019 based on 10 metrics from the World Bank's Ease of doing rankings.

Table 2 shows that India has moved up from the unenviable position of 181 in Building permits in 2018 to the enviable position of 52 in 2019. That's a huge leap forward in only a single year! India has moved up from a terrible 146th place in 2018 to an excellent 80th place in 2019 in International Trade, and from a dismal 156th place in 2018 to an acceptable 137th place in 2019 in Establishing a New Enterprise. Although there has been significant improvement, India still has a ways to go in areas like Property Registration. India dropped from a dismal 154th place in 2018 to 166th place in 2019. (2019). As compared to the average in OECD high-income nations, the 1,445 days it takes a corporation to settle a commercial dispute via a local court of first instance when enforcing contracts (163) is over three times as long. Property registration (154th); the average process takes 58 days and costs 7.8% of the property's value, both of which are more than the average in OECD high-income nations.

Table 1 : The grading of the survey by World Bank

Rankings	Grading
Rank 1 to 53	Very Easy
Ranks 54 to 97	Easy
Ranks 98 to 147	Medium
Ranks 148 to 190	Below Average

Table 2 : India's position based on sub-indices on which countries are ranked by World Bank

World Bank Indicator	2022	2019
Starting a Business	156	137
Dealing with Construction Permits	181	52
Getting Electricity	29	24
Registering Property	154	166
Getting Credit	29	22
Protecting Minority Investors	4	7
Paying Taxes	119	121
Trading Across Borders	146	80
Enforcing Contracts	164	163
Resolving Insolvency	103	108

Table 3: Sector wise allocation under AatmaNirbhar Bharat Scheme

Sector	Banking (RBI measures)	State Borrowing	Business and MSME	Agriculture	Social Sector (including PMGKY)	Power	Housing	Taxation	Health	Total
Allocation (Rs lakh crore)	5.22	4.28	3.675	3.48	2.08	0.9	0.7	0.5	0.15	20.986
Allocation as % of total package	24.4%	20%	17.2%	16.3%	9.7%	4.2%	3.3%	2.3%	1.8%	100%

Setting up a Central Monitoring Mechanism led by the chief secretary to review the SWS of various states at regular intervals, ensuring timely technological updates to the online portal, increasing the efficacy of the Right to Services Act, encouraging self and third-party certifications, etc. are all steps that could be taken to strengthen the effectiveness of the SWS across India.

Property registration and land purchase, another major problem for local companies, is time-consuming and expensive. Reforms that make it easier to register property and acquire land would benefit businesses looking to open shop or expand operations in India. Allowing businesses to purchase land from individual farmers, standardizing stamp duty across jurisdictions, digitizing and integrating land records at multiple levels, and creating a centralized point of contact for all matters pertaining to land ownership in each state are all reforms that can help.

Third, complying with labor rules is expensive despite the government's major advances. The government should propose measures that exempt industry from certain labor regulations for a period of three years in order to ease the regulatory load of compliances. The Industrial Disputes Act and the Factories Act are two examples of labor rules that might benefit from an increase in their threshold in order to boost industrial expansion. In order to increase employment flexibility, it is imperative that the "Fixed Term Employment Worker" guidelines be notified and implemented throughout states as soon as possible. Other measures that would make it simpler for companies to operate include centralizing labor regulation and decriminalizing violations of employment law.

The fourth point is that India has made significant progress in the area of trade facilitation over the last several years, moving up the 'Trading Across Borders' rating from 146th in 2018 to 68th in 2019.

There is room for additional development, which might bring India's economy up to pace with the world's top performers. Promotion of the Authorized Economic Operator programme and the Risk Management System are to be bolstered. Movement across borders might be simplified by encouraging Direct Port Delivery, creating a Single Customs Portal for essential information, and enhancing the Port Community System.

Fifth, despite the government's best efforts to improve the country's business climate, contract enforcement remains inadequate.

There are a number of steps the government may do to better the country's dispute resolution process, such as bolstering the ADR mechanism and creating model contract templates for a select number of major industries after hearing input from those in those fields. The creation of business courts and the addition of infrastructure like judges would aid in this endeavor.

7. CONCLUSION

From the ideas of our greatest philosophers like Swami Vivekananda to those of our current prime minister, the focus has been on fostering an environment and ecosystem that will allow India's youth to become the driving force behind the country's economic growth, job creation, and return to its former glory. The business's guiding principles will determine if the company or its founder succeeds. Entrepreneurship is impacted by several things, such as the originality of the business model and the availability of novel, technologically-based approaches.

Most states are developing their startup scene at a rapid clip, but those with larger populations need to pay more attention to their startup ecosystems in order to improve the conditions there. Similar attention may be needed to encourage business activity in the North Eastern States so that they may contribute to the growth of the region as a whole. The manufacturing sector will always be important to any economy because of its capacity to provide significant numbers of jobs and boost economic development. New subfields, such as Fintech, Agritech, Healthtech, Edtech, SaaS, etc., will continue to attract interest and drive the industry forward. Make in India's efforts to attract capital to strategic industries and promote innovation and infrastructure development are crucial if the country is to fulfill its potential as a manufacturing and design center. A comprehensive analysis of these changes reveals a dramatic shift from more conventional to more cutting-edge technological approaches. India's thriving startup scene is a reflection of the country's history as a center for young businesspeople, as well as the difficulties they've experienced, the factors that have shaped the ecosystem around them, and their prospects for the future. The lesson is that failure and success are necessary parts of any startup ecosystem, and that incorporating cutting-edge technologies like AI into their business models is crucial to the companies' long-term survival and profitability.

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SMART MANAGEMENT SYSTEM FOR EFFICIENT SUPPLY AND DISTRIBUTION OF DRINKING WATER

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ABSTRACT

Water in life is an accepted biological phenomenon,as it is one of the very five important elements to which human life owes its physical existence.Access to safe, clean, and affordable water is one of the most basic human needs, and it remains a major global challenge. Water supply currently faces enormous challenges in terms of both quality and quantity. The impact of water quality and quantity are very extensive on human livelihoods that include health, economy, food, energy, environment, and social impacts. India, like any other developing country, has almost exhausted all of its sources of water. Most of our known water sources are under threat of over-exploitation.Many reasons have indeed been put forward for clarifying the inadequate supply of water to the citizenry, which includes massive losses, an overage pipe system, rising water usage, and a lack of readily accessible resources. Water systems are additionally becoming more complex and instrumented, possibly requiring a diversified collection of characteristics to cope effectively with the sophistication. In this work, we seek to implement a smart water system and distribution model that will not only enhance supply system efficiency but can additionally detect imperfections and losses throughout the system.The paper suggests some techniques to reduce this influence. Water Gem and Prime Work software have assisted in the estimation of real-time water demands and their effective distribution.

Keywords: *Water Demand, Water Management, Leakage, Quality, Water Meter.*

1. INTRODUCTION

A lack of water impacts tens of billions of individuals in India. A lot of people lack a regular and trustworthy drinking water supply for about their everyday needs. In June 2019, 65% of India's reservoirs reported below-normal water depth, with 12% completely burned. [1].Even though tap water isn't really available in many cities, inhabitants

should indeed fall back on different sources of water. The region has innumerable public water pumps, but so many of them are situated far off from cities and also have infrequent and unforeseen water flow. Numerous Indians have been forced to spend money to buy drinking water, but the impoverished parts of society are unable to pay for this on a regular basis, resulting in an enormous shortage of water for India's rural populace. People's health is imperiled by limited access to water. In times of a water crisis, insufficient water has the possibility of damaging the health of an entire city.Smart water management should have included smart water meters and management, leak detection and inspection and maintenance, and monitoring of water quality in order to reform the present water supply system in line with MoUD's smart-city stated mission and regulations [2].This same overall accessibility to water resources is in potential danger as a matter of fact due to environmental conditions and developments, rising water demand, and increasing worldwide populations. Because of growing populations and poorly managed plans, urban India is confronted with severe issues such as a shortage of clean water to consume, unsanitary conditions, and a lack of funding. A smart water administration system consists of a two-way, real-time network of electronic devices and sensors that unceasingly and tangentially oversee the distribution system for water.

The following research survey reveals that innovation in water management systems brings successful results in both distribution and operation of the water supply system.

Merchant et al. (2014) introduced a new water management system with the use of software in order to shorten thegap between supply and demand faced by many Indian cities that are looking to expand. Bangalores water and sewage systems board managed to install a flow meter that transmits data through GSM and stores it in a SQL database on a SCADA server located in a centralized location[2].Bhatt (2015) discussed thata smart and sustainable city requires smart hydraulic structures, smart meters, GIS mapping, information sharing over internet connections, SCADA, and web-based communication. Water distribution models were developed using Water GEMS with GIS integration, after which a comprehensive design, procedure scheduling, loss evaluation, SCADA integration, and network simplicity were executed[3].Grayman (2015) in addition, improvements in the distribution network were demonstrated, and technological advancements in execution and water quality assurance were incorporated.They proposed using a computer-based tool, including SCADA, to integrate a fully automatic monitoring, tracking, and control system. They also addressed ways to strengthen pipe systems and how operation, surveillance, quality management, and design will contribute to significant changes in forthcoming systems for water distribution.[4,5].Parrod (2016) by assimilating SCADA and hydraulic models, the mentioned shortcomings in supply models can be encountered by operators and operating engineers. Bentley software tools and technology with SCADA system integration enable operators and service engineers to improve water supply system operation. [6].

Günthera(2015) introduced an unconventional distribution system for water equipped with a smart water distribution network that included measurement and control devices, data collection and communication, data display and management, and data fusion and analysis. According to them, the water distribution system is constantly changing and evolving. The smart water system is expected to enhance both the effectiveness and serviceability of buried infrastructure. [7].Khole et al. (2015) tried to introduce an unconventional water supply and distribution system equipped with a smart water distribution network that also included measurement as well as control devices, data collection and communication, data display and management, and data fusion and analysis. According to them, the water distribution system is constantly shifting and developing. The smart water system is expected to increase the effectiveness and serviceability of buried infrastructure.[8]. Allen et al. (2014) established a wireless array of sensors to encourage the real-time observation of water quality indexes and hydrological parameters in an extensive urban system for water distribution. The online predictor-corrector process is used to forecast future demand. A data analysis-

driven algorithm is employed to predict the subsequent hydraulic state. WaterWise SG's wireless sensor network collects and forecasts data that has been corrected using an evolutionary optimization algorithm. [9]. Pathan. (2013) sought to create a compositional layout that provides established water requirements to consumers over a long period of time. The ideal water supply network and quality of water are developed through the use of Water GEMS software, with the goal of minimizing the system's total expenditures. [10]. Jiang (2013) optimized efficient scheduling and scientific operations using dynamic pipe network hydraulic design.

To demonstrate a modern management system for the water supply network, a micro-hydraulic model of the water supply network must be built. Water GEMS can effectively simulate and manage pipeline network properties such as pipe formation, junctions, pumps, valves, and other databases. [11].Puust (2015) mentioned that now the workaround is accomplished through the use of tools that optimize storage tank levels, forecast the impacts of the control valve on leaking, and determine whether or not to replace the old pipe. Water GEMS are used to look into the different alternative solutions due to their simpler analysis approach.[12]. According to Lungariya et al. (2016), a pipe breakdown in the system interrupted the supply of water to the end user and lowered the performance of the model. In order for the existing system to function properly, evaluation, regulation, general upkeep, and rehabilitation services must be implemented. The evaluation of pressure and elevation, as well as multiple nodes and head loss, is performed by EPANET software at each pipe. [13].

In this study, we employed an electromagnetic flow meter which is wired to a transmitter that sends information about water pressure and flows to optimize the water management system and control the losses of water in various forms during distribution. Every home has a water meterconnected to it that tracks water usage. In more important or vulnerable points of the supplied network, pressure monitoring points (PMP) are available and installed. With the aid of, pressure at the network PMP, data loggers are attached to both PMP and electromagnetic flow meters. Data are generated with the assistance of Prime Work Software. Moreover, HDPE pipes and saddles are used to establish an unauthorized connection to the water supply system.

2. STRATEGIC PLANNING OF WATER MANAGEMENT SYSTEM

2.1 Survey location

In order to collect sample data, a preliminary survey was done in the Shivamogga Municipality area, under the Karnataka Water Supply and Drainage Board (KWS&DB). The water demand in the city of Shivamogga is about 84 LMD and it will increase to about 96 MLD in 2048. The overall distribution system all through the city consists of approximately 632 kilometers of pipeline piping ranging from 75 mm to 315 mm. The total annual water production in 2012 was approximately 84 MLD, and the quantity of water sold during the same period was 42 MLD, representing a 46.5% efficiency. Shivamogga's water distribution systems evolved from older systems. Mainly, the conventional water distribution system was followed for domestic purposes in Shivamogga City for a long time in the basin of the Tunga River. Some people also use bore wells, and hand pumps for their water needs. Table 1 indicates the Population of Shivamogga City.

Table : 1 Population of Shivamogga City

Year	1981	1991	2001	2011	2021	2031
Population	153,000	195,000	276,000	324,000	381,000	468,000

2.2 Methodology

Fig. 1 depicts about the methodology developed to prepare topological maps for a water supplied network. It is very important to identify the location of roads, streets, common passages, slum areas, industrial areas, commercial areas, and other distribution areas that need to be served. This information can be obtained by conducting a survey and gathering data about the local population and their water needs.

Fig. 1 : Schematic diagram of steps for designing water supply System

Customer surveys can help in understanding the population and estimating the number of people who will be using the water distribution network. This is important for determining the size of the network and the amount of water that needs to be supplied. In addition, a survey can help in assessing the water needs of customers, identifying any specific concerns they may have, and planning for future growth. Another benefit of conducting a survey is that it can help in determining the purchasing power of customers. This information can be used to set prices for water and ensure that it is affordable for different segments of the population. Overall, a customer survey is an important step in designing an effective water distribution network. It can provide valuable insights into the needs and concerns of customers and help in designing a network that is efficient, reliable, and scalable. Finally, conducting a customer survey can provide valuable insights into the needs and concerns of customers, which can be used to design an effective water distribution network that meets the needs of the community.

2.3 Population Forecasting

Population forecasting is an important factor in designing an effective water distribution network. A water distribution network must be designed to meet the current and future water demand of a community, and accurate population forecasting is essential in determining future water demand. By forecasting the population growth rate, water utility providers can estimate future water demands and design the network accordingly. This information helps water utility providers plan for future investments, including water treatment and storage facilities, as well as infrastructure improvements and maintenance. Population forecasting can also help to identify areas of high water demand, such as new housing developments, commercial centers, or industrial areas, which may require additional water infrastructure to meet the growing demand. Therefore, accurate population forecasting is critical in developing a water distribution network that is sustainable, efficient, and effective in meeting the current and future water needs of a community.

2.4 Design Water Distribution Network

To design an effective water distribution network, designers need to know the water demand. This can be calculated by determining the population that will be served by the network and the expected water consumption per capita. There are several methods to calculate water demand, such as Hunter's Curve, Fixture Unit Method, and the Population Method. Now a day Water Gem and Eplanet software are used for design purposes.

Whenever the design discharge is identified, the size of the pipe is assumed to be in the range of 0.6 to 3 m/s. The head losses in the pipe are then calculated using Hazen William's Formula, which is shown below.

$$V = 0.849 \times C \times R^{0.63} \times S^{0.54} \quad \text{.....(1)}$$

Where, C= Coefficient of Roughness, R= Hydraulic radius in m, S= Hydraulic gradient= Mean Velocity of flow in Pipe in m/s,D= Diameter of Pipe.

The discharge (m^3/s) is calculated by

$$Q = 0.278C \times D \times 2.63S \times 0.54 \quad \text{.....(2)}$$

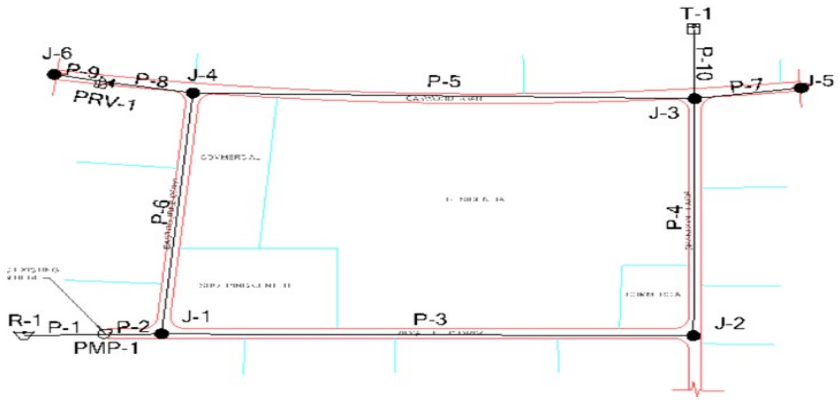

Fig. 2: Schematic diagram of Water Supply inflow System

2.5 Smart Water Management System

2.5.1 Data Accusation

A "smart water management system," which would be based on technology, is intended to enhance the efficacy and effectiveness of water delivery, management, and consumption as shown in Fig.3. It optimizes water supply and demand, detects leaks, cuts down on waste, and monitors and controls water usage using sensors, data analytics, and other cutting-edge technology. The flow rate and pressure of water in the distribution system are measured using an electromagnetic flow meter with a data logger. It is based on the electromagnetic induction concept, which employs a magnetic field to cause a conductor to experience a voltage as it passes through the field.

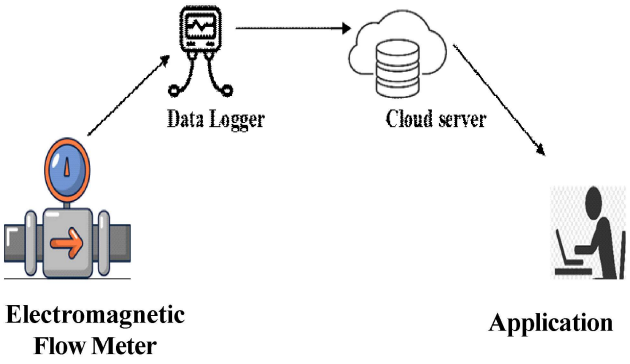

Fig 3 : Schematic diagram of Smart Water Management System

Pair of electrodes that are positioned on either side of the flow stream make up the electromagnetic flow meter. A transmitter that creates a magnetic field across the flow route is attached to the electrodes. The electrodes monitor the voltage that the magnetic field creates in the liquid as it moves through it. The voltage signal is subsequently transmitted to a data recorder, which logs the temperature, pressure, and other characteristics in addition to the flow rate, as shown in Fig 4. Other capabilities offered by the data logger could include data storage, real-time monitoring, and alert functionality.When precise flow measurement is required, such as in the manufacture of food and beverages, chemicals, and water and wastewater treatment, electromagnetic flow meters with data recorders are frequently utilized.

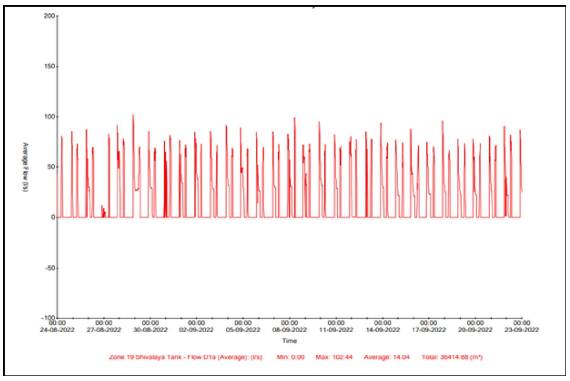

Fig.4 : Water Flow and Pressure graph

2.5.2 Meter Reading

Every house is connected to smart water meters that measure the consumption of water. These Smart meters provide real-time data on usage and help to optimize Water usage and reduce waste. This benefits both the residents and the utility company by promoting more efficient use of resources and reducing costs. The meter reading with corresponding bills is shown in Fig.5.

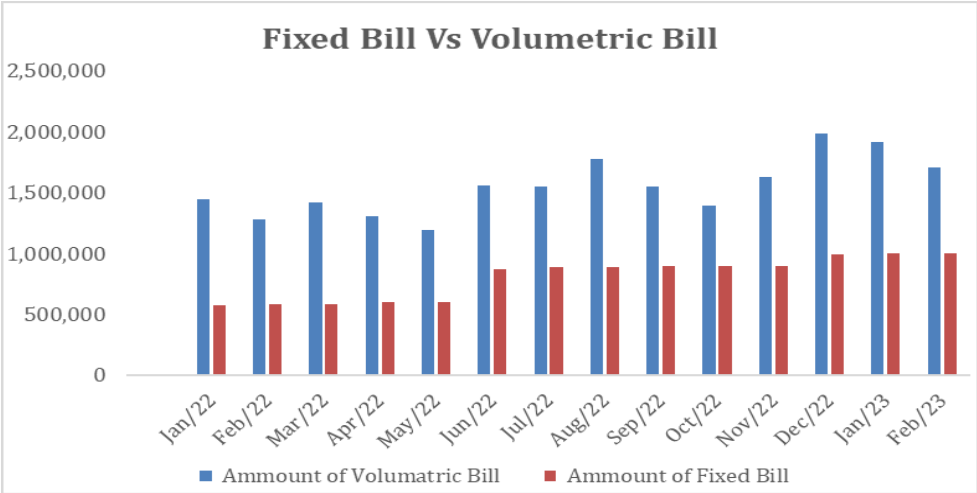

Fig.5 Fixed Bill Vs Volumetric Bill

2.5.3 Water Loss

Water is lost as a result of leakage or theft. The Water Authority loses money. Water loss can be determined by calculating the disparity between the amount of water supplied and the amount of water consumed, as calculated by the flow meter reading and the smart water meter reading at the consumer point.

$$Waterloss = \frac{(Water\ Supplied - Water\ Consumed)}{Water\ Supplied} \times 100 \quad .....(3)$$

This data allows the administration to place more emphasis on regions that have the greatest water losses and reduce them.

2.5.4 Non-Revenue Water

Non-revenue water (NRW) is a metric used by water boards to calculate how much water is lost or unrecorded in the water distribution system. Using monitoring technologies, the volume of water entering the system is computed, and billing data are used to determine the volume of water sold or billed to customers. The NRW % can be used to find and fix leaks, inaccurate metering, and other problems in the distribution system by calculating the difference between these two figures.

2.5.5 Quality Check

Several methods are used to collect water samples for the purpose of chemical or physical testing, based on the degree of accuracy required and the character traits of the contaminant. As shown in Fig. 6, samples are collected from various locations, and analysis samples are created for water quality testing.

Fig.6 : (a) Onsite pH Test

(b) Onsite Residual Chlorine Test

3. CONCLUSION

The primary focus of this paper is to modernize the conventional system for water distribution. Users may suffer as a result of water loss in the system. It is critical to detect losses in order to guarantee sufficient supply. As a matter of fact, by using modern tools and equipment, the system may be able to work more efficiently. The system will be a great deal more straightforward to use with Water GEMS, and any problems will be easily tracked by the software. There are many different kinds of tools that are used in the water supply and distribution systems, which are discussed in various literature sources, but Water GEMS is more accurate than others.

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EFFECT OF NUTRITIOUS FOOD AND YOGA TRAINING ON COORDINATION OF MALNOURISHED STUDENTS

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ABSTRACT

The purpose of this study was the effect of a nutritious diet and yoga conditioning training on malnourished students. We investigated the effects of high diet and yoga training. The subjects were 45 girls from Weygand District, Kerala, India. According to medical expert diagnosis, these students were identified and randomly divided into her three groups. The first experimental group was nutritious food, the second experimental group was yoga training, the second group was yoga training only, and the third group was the control group. Nutrition and yoga training followed his ten weeks. Adjustment was measured by action-reaction time. Pre-test data were collected first, and post-test data were collected after a 10-week training period. The data collected were for adjustments. The information acquired had been statistically analyzed through evaluation of covariance (ANCOVA) to locate enormous variations among means. If enormous consequences had been acquired, a put up hoc test (LSD test) became carried out to decide enormous variations among paired means. The significance level for checking the F value was set at 0.05. A 10-week systematic sports training and nutritious diet and yoga training program showed significant improvement in coordination in selected subjects.

Keywords:- *Yoga, Malnourish*

1. INTRODUCTION

Today the biggest problem of the mankind is malnutrition. The question of malnutrition arises when an individual does not receive proper nutrients needed to keep the body healthy. There are a large number of people suffering from malnutrition and lack of proper nutrition.

According to a survey conducted by the United Nations Food and Agriculture Organization, one person in every eight persons is suffering from malnutrition. Even in the developed nations a total of 32.5 percent of children are malnourished. The major reason of death behind the 14.5 percentage children in the age group of one to five years is starvation. The same reason is observed in the death of adults. Common motor fitness which is a power is not only present in human being but it is there in all the living being on the planet. However, this can be classified into different categories. It is a well-known fact that all direct and indirect dynamic elements are responsible for good looks. For example, after the analysis of twenty-eight variables normal motor ability test is prepared. Out of which the main elements are strength (power), velocity and muscle co-ordination. However, the other

components such as body size, height, weight, strength, endurance, balance and agility are equally important.

Yoga is a Sanskrit word it is derived from the Sanskrit root "yuj," (pron."yug") which means metal and the connection of the articulation. Yoga helps in connecting our soul with the spiritual world. With the help of spiritual Yoga and God's connection Karma yoga skills, the mind's tendencies detention and tool - seeker method of procurement is also called. Yoga is a science to coordinate the entire body and mind. Yoga is as old as the Vedas. Yoga also finds mention in the Vedas. Yoga is live practice.

The sun gives us the power for life. It is called 'Prana' in Sanskrit. Another aspect of Pranayama is exhaled breath. Therefore it is worth pointing out that the effect of it on our body. While resting man does not exhale all the air in the body. Before his breaths the fresh air 1650 cubic centimeters of air is already present in the lungs. Which means not more than 21 % fresh air is present in the lungs.

2. OBJECTIVE OF THE STUDY

The objective of the study "The Effect of Nutritious Food and Yoga Training on Coordination of Malnourished Female Students"

2.1 Selection of Subjects

For this research effect of nutritious food and training of yoga on Coordination in malnourished female students among secondary school malnourished female students was studied. Subjects were forty five secondary school girls from weyanad District which is situated in Kerala state. As per the diagnosis of expert doctor these students were identified and randomly divided into three groups. One group was for nutritious food and yoga training, the second group was only yoga training and the third group was controlled. The nutritious food and yoga training was for a period of 10 weeks.

2.2 Criterion Measures

Sl. No.	Variables	Test/Equipment's	Measurement
1	Coordination	Action-Reaction time	Time

2.3 Statistical Procedure

First the pretest data was collected and after a training period of ten-weeks post-test data was collected. The collected data was about Coordination. The data obtained were statistically analyzed by analysis of covariance (ANCOVA) to find significant differences between means. If significant results were obtained, a post hoc test (LSD Test) was applied to determine significant differences between paired means. The significance level for checking the F value was set at 0.05.

The 'F' ratio of the pre-test mediums of the Coordination test performance was found to be 2.916. Which was not found to be meaningful at the level of (2,42) 0.05 compared to the table value. The 'F' ratio of the median of the post test of the three groups was found to be 1.982. Which was not found to be meaningful at the level of (2,42) 0.05

Table 1 : Means and Analysis of Covariance of Coordination Test for Nutritious Food and Yoga Training and Controlled Group

Test	Mean			Sum of square (SS)	Degree freedom *(df)*	Mean sum of square (MSS)	*'F'*
	Group-A	Group-B	Group-C				
Per test Mean	18.24	16.466	15.76	48.972	2	24.486	2.916
				352.645	42	8.396	
Post test Mean	17.54	15.66	15.813	33.421	2	16.710	1.982
				353.969	42	8.427	
Adjusted Mean	16.164	16.010	10.859	5.887	2	2.938	9.935*
				12.126	41	0.295	

***Significance Level at 'F'**(2,42), (2,41) = 3.21

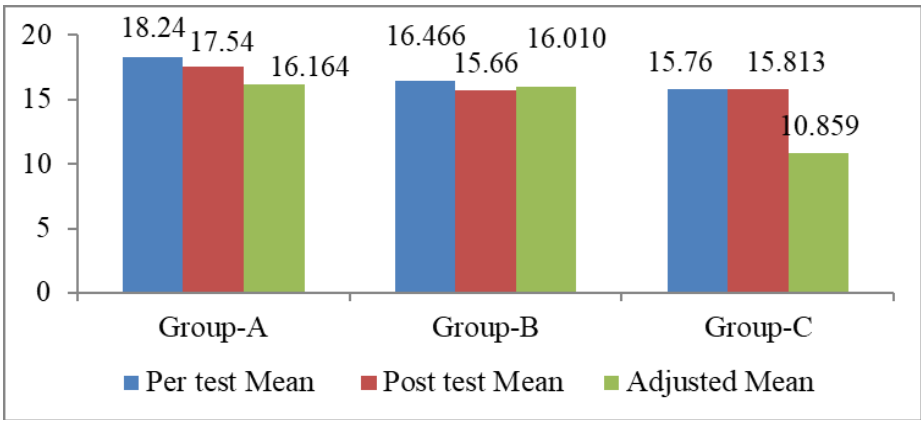
compared to the table value. Also the 'F' ratio of the revised mediators (Group-A = 16.164, Group-B = 16.010 and Group-C = 16.859) was found to be 9.935. Which was found to be meaningful at the level of (2,41) 0.05 compared to the table value.

The information shown in the Medium Difference column shown in the table-2, the differences between the pairs of groups A-B,A-A and B-C, compared to the radical difference in which group improved with the given nutritious diet and yoga training. It becomes easier to understand. The above table showed a significant improvement in both the group-A supplementary diet and yoga training and the group-B yoga training experimental group compared to the control group. The median of which is shown in Graph-1.

Table 2 : Means and Least Significant Difference of Coordination Test for Nutritious Food and Yoga Training and Controlled Group

Mean			Mean Different	Critical Different
Group-A	Group-B	Group-C		
16.164	16.010		0.154	0.400
16.164		16.859	0.695*	
	16.10	16.859	0.849*	

Significance Level



Graph 1 : Graphs showing the median of the Coordination test

3. CONCLUSION

Ten weeks systematic sports training, Nutritious Diet and Yoga Training program showed a significant improvement in the Coordination of the girls who were the subjects for this study.

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REGIONAL DISTRIBUTION OF FOREIGN DIRECT INVESTMENT INFLOWS TO INDIA

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ABSTRACT

The inward FDI flows data from year 2000-01 to year 2018-19 to India was analyzed using percentage, compound growth rate and ARIMA model. The results clearly show that there is skewed distribution of FDI inflows and large number of states of India failed to get benefited from FDI inflows. The states benefitted most are Andhra Pradesh, Dadra & Nagar Haveli, Diu & Daman, Delhi, Gujarat, Karnataka, Maharashtra, Parts of Haryana and UP, Pondicherry, Tamil Nadu, and Telangana. The projections of FDI inflows in India from 2019-20 to 2024-25 by ARIMA models show that the FDI inflows in India are likely to increase at CAGR of 4.03%, 3.49%., 3.73%.7.73%, 8.48%, 3.74% and 3.58 % at ROM, ROD, ROB, ROC, ROA, ROH and RNI respectively.

Keywords: *ARIMA, FDI inflows, Compound annual growth rate, reforms, trend*

1. INTRODUCTION

India has long history of FDI inflows, the most prominent being East India Company establishment by the British. At the time of attainment of independence India had comparatively limited inward FDI in consideration to other countries of the world which were seeking to become more advanced economically. This was due to restriction put on foreign investments and slow and complicated approval process procedure. Therefore, flow of inward FDI in India was very low up to 1990.This situation changed after the Government of India launched the economic reforms in 1991 with undertaking of large scale measures of liberalization process. This liberalization and globalization of economy lead to massive increase in FDI inflow from US $ 129 million in 1991-92 to US $ 44366 million in 2018-19. FDI inflows played significant role in economic development in India being important resource of non-debt financial resources. FDI inflows helped in development of Indian economy by creation of jobs, infrastructure development and establishment of forward and backward linkages to Indian companies. Tremendous growth of FDI inflow in India since 2004-05 is mainly due to improvement in infrastructure and business environment and Government policies such as procedural simplification and inclusion of more and more sectors under automatic routes. India has emerged as one of the leading destinations in recent years; however, there is FDI inflows in large amount in selected regions of India. The regions comprising of economically developed states accounted for lion's share of inwards FDI flows in the country.

2. REVIEW OF LITERATURE

Pandhi [1] reported that FDI inflows in India concentrated in the states having good

infrastructure and manufacturing bases in comparison to the states not having equally good facilities. Morris [2] stated that states having big cities attracted more FDI inflows in India. Mukherjee [3] concluded that there is strong regional concentration of FDI inflows growth in India. Singhania and Gupta [4] examined the factors which decisively affects of foreign direct investment flow in the country. The best fit ARIMA model to explain variation in FDI inflows into India was found using macroeconomic variables. Anitha [5] analysed FDI inflows in the country for the Post Liberalization period. FDI inflow to India during Post Liberalization period for five years period was projected making use of ARIMA forecasting technique. Akhtar [6] observed that FDI grew at annual growth rate (compound) of 19.05% and 24.28% through the period of pre liberalization and post liberalization respectively. FDI inflows to India grew about 165 times since 1991. Wellington and Jammu [7] analyzed inflows of FDI during the period 2000-2010 in terms of sectors and destination states.

The six states and seven sectors accounted for about 96 % and 88 % respectively of FDI inflow to India during the study period. Biswas [8] applied ARIMA model to time series data of 1992-2014 of FDI inflow and showed that FDI inflows follows an increasing trend over the forecasting period (2015-2034). Malleshppa and Vasudev [9] observed that though India progressed well in attracting FDI inflows but the flow is largely concentrated in few economically developed states viz. Andhra Pradesh, Delhi, Gujarat, Karnataka, Maharashtra and Tamil Nadu. These states accounted more than 70 % of FDI inflows in India from 1990-91 to 2015-16 and harvested benefits of globalization. Das [10] studied the trend of FDI inflows, its route, sources and sector wise distribution of inward FDI flows to India. It was found that most of the flows to India are through automatic route and acquisition of existing share route. Most of the inflows moved to the services and telecommunications sectors and less to manufacturing sector. Saravannan et al. [11]) detailed state-wise FDI inflows to India from August 2001 to August 2008 in terms of number of projects. Six states namely Maharashtra (19.85), Delhi (11%), Tamil Nadu (10.58%), Karnataka (10.30%), Andhra Pradesh (5.08%) and Gujarat (4.87%) accounted for highest number of projects during the study period.

3. RESEARCH METHODOLOGY

The financial year (time series) data used in this study are obtained from RBI website and DIPP website. This study used percentage, compound growth rate and ARIMA model to analyze the FDI inflows time series data. Graphical tools (bar and pie charts) are used for analysis in this study. The study is an attempt to achieve following objectives:

1. To examine regional pattern of FDI inflows and its trend in India
2. To quantify states wise volume of FDI inflows up to 2024-25

4. RESULTS AND DISCUSSION

4.1 States wise Trend of FDI Inflows in India

The total FDI inflows to India grew from US $ 2463 million in year 2000-01 to US $ 44346 million in year 2018-19 showing an increase of 18 times. The FDI inflows in India grew at annual growth rate (compound) of 16.43% during the period. The FDI inflow to India has an increasing trend and recorded tremendous growth. Although FDI inflow recorded rapid increase during the study period, but the states wise distribution of FDI inflow is skewed. The states covered under the jurisdiction of Mumbai RBI regional office received highest amount of FDI followed by Delhi, Bangalore, Chennai, Ahmadabad and Hyderabad. Therefore, in this study states covered under these six regions of RBI and remaining states of all the other regions taken together have been selected for study. The details of the RBI regions and states covered under them with notations used in this study are given in Table1.

The share of FDI inflows to total inward FDI flows to India between January 2000 to March 2005 and between January 2000 to March 2019 at ROM, ROD, ROB, ROC, ROA, ROH and RNI are shown in Figure 1 and Figure 2 respectively. It is revealed that share of FDI inflows at ROM (26 %), ROD (21 %), ROB (8%), ROC (6%), ROA (3%) and ROH (3%) from January 2000 to March 2005 period was 67 % and it increased to 75 % between January

Table1 : Details of states covered under RBI's regional offices

RBI's regional offices	States covered	Notations
Mumbai	Maharashtra, Dadra, Diu and Daman	ROM
New Delhi	Delhi, parts of Haryana & Uttar Pradesh	ROD
Bangalore	Karnataka	ROB
Chennai	Tamil Nadu and Pondicherry	ROC
Ahmadabad	Gujarat	ROA
Hyderabad	Andhra Pradesh and Telangana	ROH
All Regions not indicated above	West Bengal, Sikkim, Kerala, Andaman, Chandigarh, Bihar, Assam, Punjab, Goa, Haryana, Himachal Pradesh, Madhya Pradesh, Uttar Pradesh, Rajasthan, Uttarakhand, Chhattisgarh, Orissa, Lakshadweep, Jharkhand, Tripura, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Jammu and Kashmir and Ladakh	RNI

2000 to March 2019 period. The comparison clearly shows that foreign investors are moving to more preferred regions i.e., ROM, ROD, ROB, ROC, ROA and ROH for investment and not willing to move to least preferred regions i.e., RNI for investment. The study clearly indicates the need of policy intervention by Government of India and states government of least preferred region.

The total inward FDI flow to India in year 2000-01 was US $ 2463 million. Procedural Simplification for approval and the fact that more and more sectors were included in automatic route resulted in increased FDI inflows in India (US $ 5540 million) in 2005-06. FDI inflow in India from 2005-06 onward continued to have in general an upward trend. Therefore in this study, destination of FDI inflow in India is studied from 2005-06 to 2018-19. The trend of percentage of FDI inflows received from January 2000 to March of each financial at ROM, ROD, ROB, ROC, ROA, ROH and RNI are shown in Figure 3. The Figure 3 reveals that the range of share of FDI inflows (%) in India received at ROM, ROD, ROB, ROC, ROA, ROH and RNI from January 2000 to March of each year i.e., end of each financial year are 24%-36%, 15%-23%, 6%-9%, 5%-8%, 3%-6%, 3%-5% and 24%-35% respectively. ROM is the highest recipient of FDI inflows with 30% of total inward FDI flows between January 2000 to March 2019 followed by ROD, ROB, ROC, ROA and ROH with 20%, 9%, 7%, 5% and 4% of total FDI inflows in India respectively. All other states (RNI) taken together received 25 % share of FDI inflows. In case of RNI the share of FDI inflow received from January 2000 to march 2006 at RNI was 33% of total FDI inflows and it reduced to 25% of total FDI inflows in India from January 2000 to March 2019.

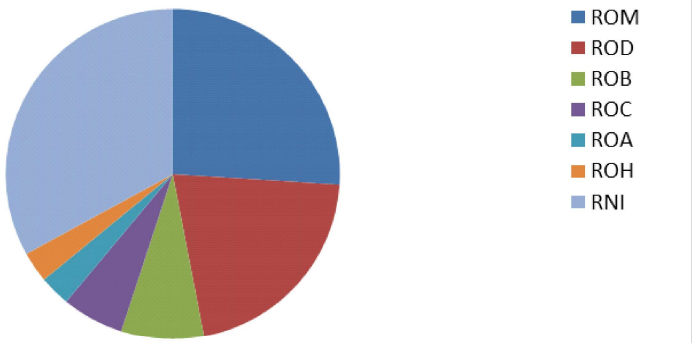

Fig 1. FDI inflows share (%) from January 2000 to March 2005

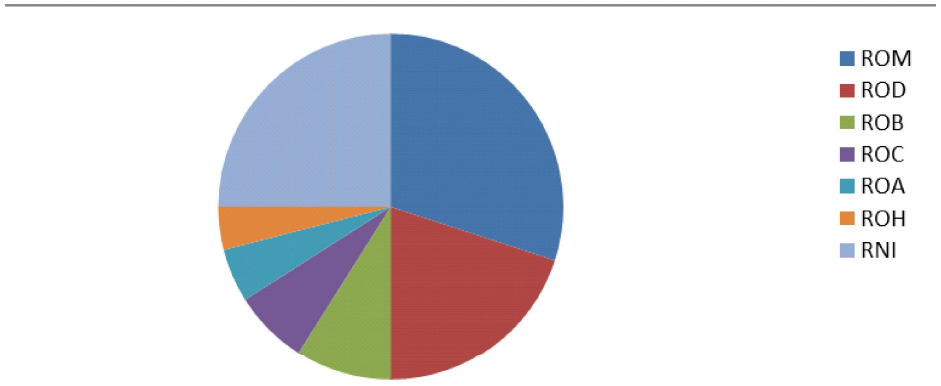

Fig. 2. FDI inflows share (%) from January 2000 to March 2019

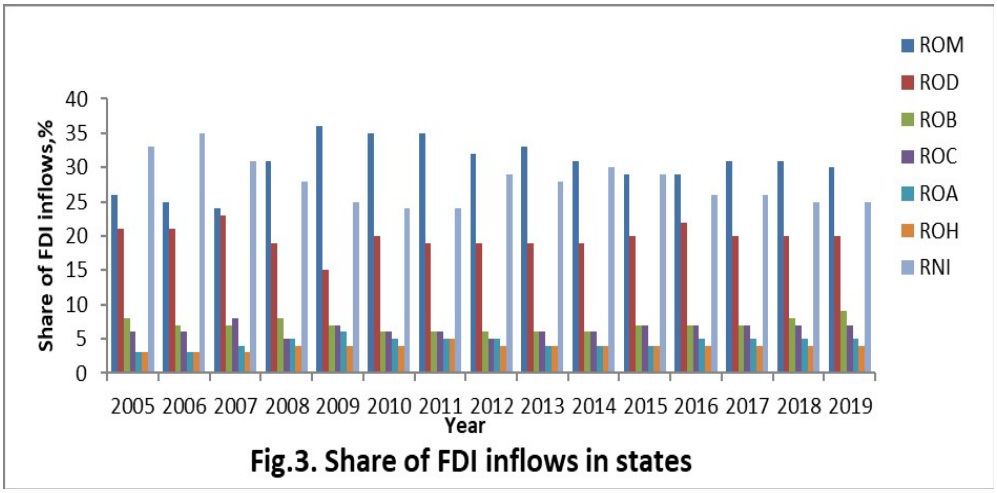

Fig.3. Share of FDI inflows in states

The FDI inflows received at ROM and ROD (Dadra, Daman and Diu, Maharashtra, Delhi, parts of Haryana and UP states) from January 2000 to March 2019 is 50% of total FDI inflows in India. The FDI inflows received at ROB, ROC, ROA and ROH (Karnataka, Tamil Nadu, Pondicherry, Gujarat, Andhra Pradesh and Telangana states) from January 2000 to March 2019 is 25% of total inward FDI flows in India. It clearly shows skewed distribution of FDI inflows in India. Due to which large number of states failed to reap benefits of FDI inflows. Thus, opportunities to the Indian companies located in these states for technology advancement, skill up gradation, infrastructure development and management were not available. The states/ union territories benefitted most are Andhra Pradesh Dadra Nagar Haveli, Diu & Daman, Delhi, Gujarat, Karnataka, Maharashtra, Parts of Haryana and UP, Pondicherry, Tamil Nadu and Telangana.

The trend of financial year wise FDI inflows at ROM, ROD, ROB, ROC, ROA, ROH and RNI from 2005-06 to 2018-19 are shown in Figure 4. Figure 4 clearly depicts regional disparities in terms of FDI inflows in different regions of the country. The Figure 4 shows a rising trend of FDI inflows in India at ROM, ROD, ROB, ROC, ROA, ROH and RNI. The FDI inflows in all states dropped in year 2009-10, 2010-11 and 2012-13 due to global economic recession and but FDI inflows to India recovered thereafter. The flow of FDI in all states slackened in 2017-18 and 2018-19 thus showing a decreasing trend. The FDI inflows in India grew at compound growth rate of 19.24%, 17.66%., 22.07%, 17.66%, 22.35%,21.06% and 12.87 % at ROM, ROD, ROB, ROC, ROA, ROH and RNI respectively from 2005-06 to 2018-19.

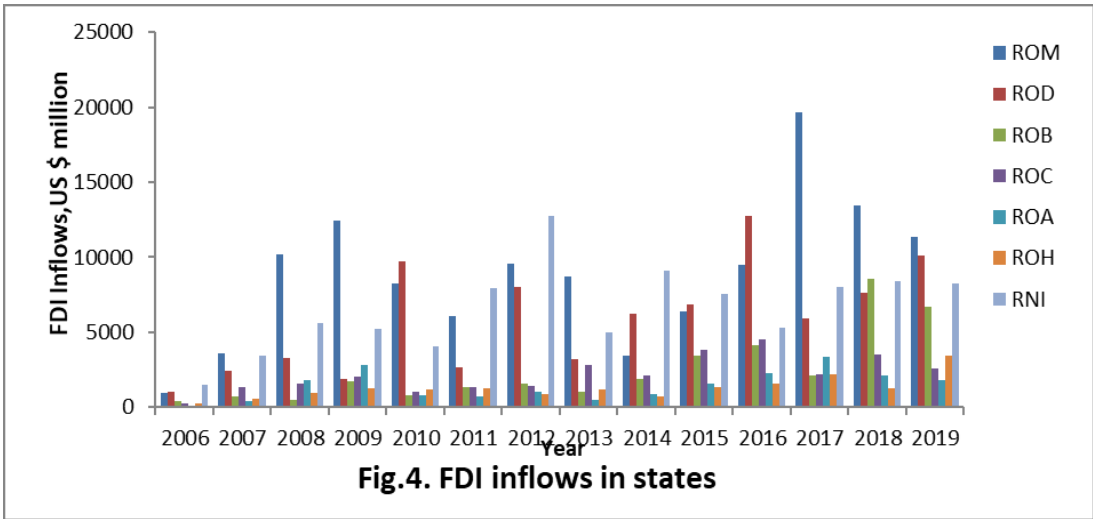

Fig.4. FDI inflows in states

2. FORECAST OF STATES-WISE VOLUME OF INWARD FDI FLOWS TO INDIA

ARIMA(p,d,q) models were employed to forecast FDI inflows at ROM, ROD, ROB, ROC, ROA, ROH and RNI over the period beyond the study period i.e.; from 2019-20 to 2024-25 using annual time series data of FDI inflows at these states. The time series data were differentiated because in general economic variables time series data are non-stationary. The non-stationary time series was transformed by differentiating into stationary series for further analysis. Eight ARIMA models used in this study are: ARIMA (110), ARIMA (011), ARIMA (111), ARIMA(210), ARIMA(211), ARIMA 212), ARIMA(012) and ARIMA(112). The accuracy of results of models was checked using Akaike Information Criterion (AIC). The model which gave lowest value of AIC was used for predicting of FDI time series data. Based on minimum value of AIC, it was observed that ARIMA (212) is the best suited model for FDI inflows at ROM, ARIMA (012) model for FDI inflows at ROD, ARIMA (112) model for FDI inflows at ROB, ARIMA(011) for FDI inflows at ROC, ARIMA(111) for FDI inflows at ROA, ARIMA(110) for FDI inflows at ROH and ARIMA(111) for FDI inflows at RNI. The forecast of FDI inflows at ROM, ROD, ROB, ROC, ROA, ROH and RNI from the selected models are shown in Figure 5 over the period of 2019-20 to 2024-25. The total volume of FDI inflows at ROM, ROD, ROB, ROC, ROA, ROH and RNI are projected to be US $ 14774 million, US $ 12902 million, US $ 8690 million, US

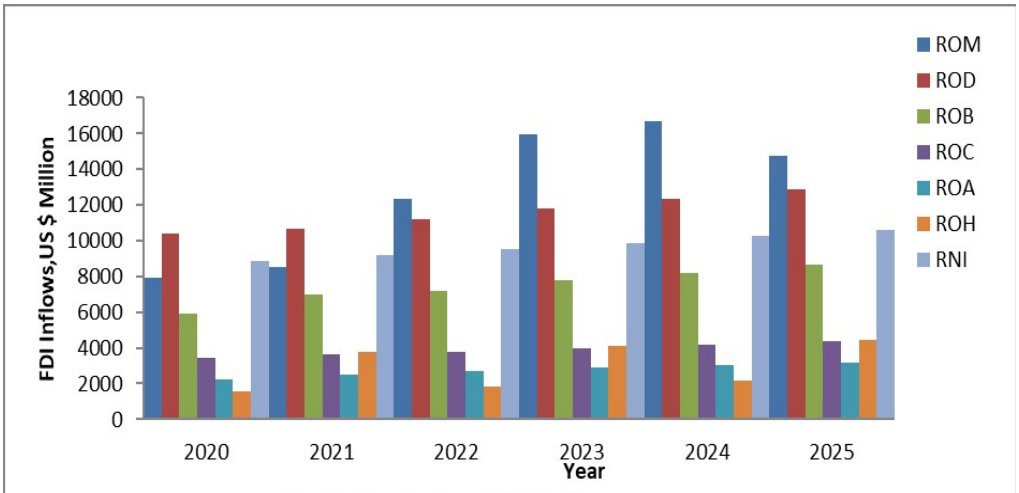

Fig 5. Projected FDI inflows

$ 4403 million, US $ 3189 million, US $ 4471 million and US $ 10577 million respectively in 2024-25 according to ARIMA models used for forecasting.

The projections of FDI inflows in India at ROM, ROD, ROB, ROC, ROA, ROH and RNI from 2019-20 to 2024-25 show that the FDI inflow will have an upward trend from the period of 2019-20 to 2024-25. The FDI inflows in India are likely to increase at growth rate (compound annual) of 4.03%, 3.49%, 3.73%, 7.73%, 8.48%, 3.74% and 3.58 % at ROM, ROD, ROB, ROC, ROA, ROH and RNI respectively.

3. CONCLUSION

The FDI inflows exhibit a positive growth trend over study period in spite of global crises. ROM is the highest recipient of FDI inflows with 30% of total FDI inflows from January 2000 to March 2019 followed by ROD, ROB, ROC, ROA and ROH with 20%, 9%, 7%, 5% and 4% respectively. The states/ union territories benefitted most from FDI inflows are Andhra Pradesh, Dadra & Nagar Haveli, Diu & Daman, Delhi, Gujarat, Karnataka, Maharashtra, Parts of Haryana and UP, Pondicherry, Tamil Nadu, and Telangana. The projections of FDI inflows in India at ROM, ROD, ROB, ROC, ROA, ROH and RNI for the next five years show that the FDI inflows will have an upward trend up to 2024-25. The FDI inflows in India likely to augment at growth rate (compound annual) of 4.03%, 3.49%, 3.73%,7.73%, 8.48%, 3.74% and 3.58 % at ROM, ROD, ROB, ROC, ROA, ROH and RNI respectively.

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THE IMPLICATIONS OF IOT ON PHOTOVOLTAIC (PV) SOLAR ENERGY

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ABSTRACT

Solar power is one of the most alluring renewable energy sources available today. Solar energy can be collected through the use of photovoltaic (PV) systems, which convert light into direct current electricity. Photovoltaic systems can be installed everywhere there is sufficient potential energy. Monitoring PV system performance is difficult since it depends on a wide variety of system settings and parts. Therefore, a real-time monitoring system should be used to evaluate the system's efficacy. Using IoT for performance-based monitoring and control of PV systems is the focus of this study. Particular attention is paid to the importance of the Internet of Things (IoT) and its implications for the design of photovoltaic (PV) systems. In general, IoT aids in understanding operational factors in real time. The organization can gain system management, fault diagnosis, and maintenance speed and efficiency by inspecting, diagnosing, and maintaining all of the distributed solar power systems in places far from service centres. The effects of the Internet of Things on solar power generation, monitoring, and other topics are discussed in this study.

Keywords : *Internet of Things, IoT, photovoltaics, monitoring, solar*

1. INTRODUCTION

Solar photovoltaic (PV) systems are a primary source of renewable electricity in many nations. The most effort should be put towards optimizing the generation potential of photovoltaic systems. These possibilities are influenced by a variety of factors, including possible technology, geography, and others. Cost per kilowatt-hour, return on investment, and payback time are all affected by how much power can be generated [1]. It is also important to take steps during each solar system installation to maximize the energy output. There may be problems with the performance or functioning of the system during operation, despite the efforts made during installation and beforehand. Solar systems in outlying areas or at a great distance from the home may be more susceptible to seeking issues [2].

Therefore, an appropriate remedy must be employed to resolve these problems. The most effective method of dealing with this is to keep close tabs on your development. Focus, diligence, and precision in problem identification and resolution are among man's greatest challenges. [3]. The Internet of Things (IoT) is a rapidly growing technology that

may be used for remote monitoring, making it a promising solution to this kind of issue. In IoT, every piece of technology, including every piece of communication equipment, is linked together and to the internet. Most of the things we encounter on a daily basis (cameras, household appliances, displays, automobiles, actuators, sensors, etc.) may be easily interacted with thanks to devices like micro controllers, digital communication tools, transceivers, and information and network protocols. [4, 5].

The application will be able to gather a vast amount of data about items with the use of this cutting-edge tech, data that can then be utilized to inform the creation of new types of technological advancements. As a result of the proliferation of IoT-related application domains like healthcare, industrial and home automation, home energy management, renewable energy systems, medical aids, and traffic maintenance, practically every use case imaginable can be considered. [5, 6]. One of the most important current applications of IoT is in the field of solar photovoltaics. This is due to the widespread adoption of distributed level generation (also known as distributed solar power) in the modern energy market. With solar PV's rising popularity, there is a great potential to include IoT systems. Both IoT service providers and their clients benefit greatly from this development. Figure 1 depicts working of a Solar System.

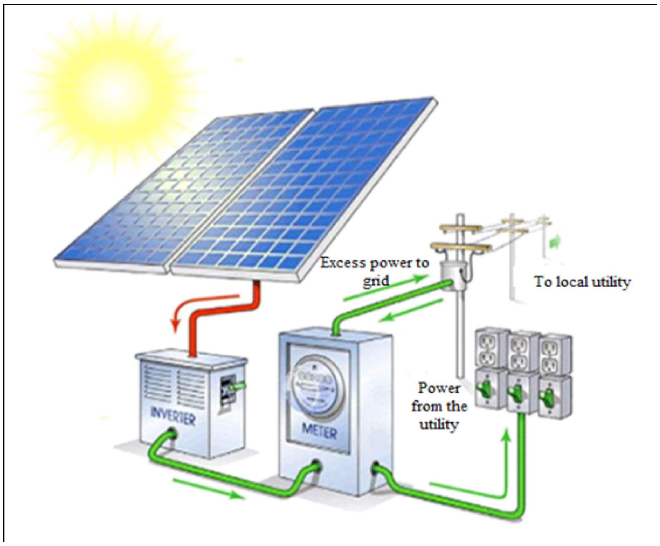

Fig. 1: Working of a Solar System

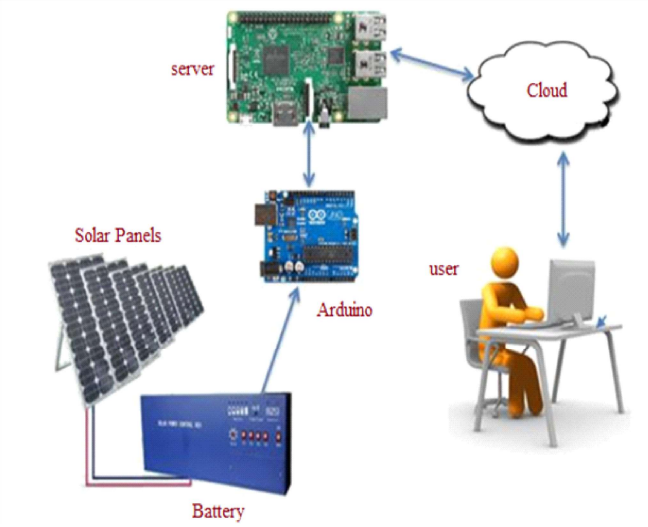

Fig.2 : IoT working with Solar Plant

Figure 2 displays an IoT working with Solar Plant. The IoT consists of Arduino, battery, cloud, server with a user.

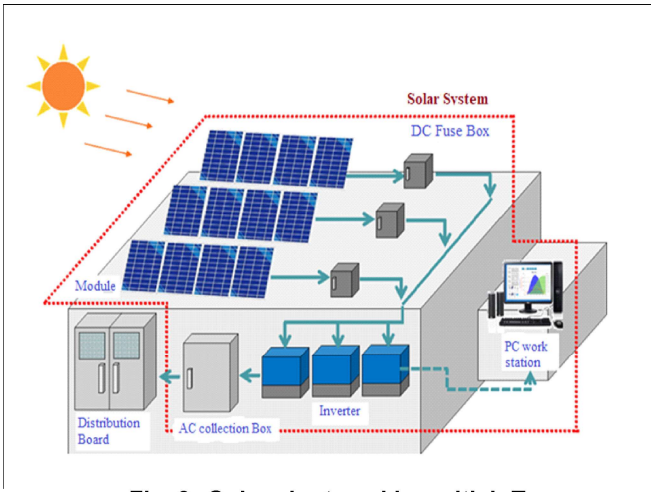

Fig. 3 : Solar plant working with IoT

Figure 3 depicts components of a solar PV system while The Internet of Things (IoT) can be realized with the use of numerous technologies, including but not limited to sensors, microcontrollers, microprocessors, mobile networks, GSM, GPRS, RFID, Wi-Fi, GPS, and microchips. Many developments in the realm of the Internet of Things (IoT) can be categorized as either empowering, accessible, or convenient. to give "things" the ability to consider their surroundings. Data processing is essential, and encouraging creativity in the process is crucial.

When you take in new information and digest it appropriately, you lay the groundwork for a deeper comprehension. This is when the most noticeable difference between the IoT and the regular internet becomes apparent. We have used Internet of Things (IoT) principles to address the main drawbacks of solar energy electricity generation. The amount of sunlight that reaches Earth's surface fluctuates over time. Ranges are unique to each user since they rely on factors such as location, time, and weather. This ensures that the solar panel receives sunshine continuously throughout the day. This means the solar panel can be tracked remotely via the IoT. The piezoelectric principle has emerged as the most promising of the technologies explored for the solar panel tracking system using IoT.

2. LITERATURE REVIEW

In order to detect and fix defective solar panels in a timely manner, P. C. M. Carvalho [5] recommended designing and developing a solar panel monitoring system. The current state of affairs has been attributed to the monitoring and automated data logging of distributed solar panels. This system can operate from a voltage range of 146 V and a current rating of 15.5 A, with the help of an automatic selection of the optimal resolutions. The price tag for using their method is 12,000 Indian Rupees.

In a report published in June of 2006, researchers gave the first comprehensive characterization of the performance and dynamic behavior of solar systems. There is now a method to quantify and assess information from multiple sources. It's capable of providing both instantaneous and real-time data measurements. Quick, secure, and reliable performance analysis are all outcomes that could arise from evaluating a PV system that is compatible with the system database. A PV system's malfunction diagnosis can be assessed in real time with the use of simulation and monitoring data integration [7].

In a report published in June of 2006, researchers gave the first comprehensive characterization of the performance and dynamic behavior of solar systems. There is now a method to quantify and assess information from multiple sources. Validity of simulation findings can be assessed by comparing them to real-time measurements. quick reaction As a solution to the existing problem of monitoring photovoltaic (PV) systems, especially in developing nations or distant places, an open-source electronic platform data logger based on the Arduino platform was created. This data logger has 8 analogue inputs and a resolution of 18 bits, making it suitable for measuring PV modules. The project managers also mentioned that each project can have its own $6,000 data logger configured to meet the specific needs of the project [8].

In this setup, host computers work in tandem with other technologies like as wireless sensor networks, ARM gateways, and remote monitoring and reverse control. Gad et al. [9] created a cheap, sensor-based microcontroller data gathering system to track the temperature of solar installations. Date and time, sample rate, and handling power outages are just a few of the experiment-specific settings that we've made flexible. There is no need for extra computer storage because the system can store data for up to 16 sensors. Every day, a fresh SD card file is produced to store the system's latest data. Excel and MATLAB are two widely used programs that make data management and analysis a breeze. The system allows for remote control of the sensors over the internet. Preparing the system database for use in PV system evaluation allows for a thorough and trustworthy examination, yielding safe and accurate results. A PV system's malfunction diagnosis can be assessed in real time with the use of simulation and monitoring data integration.

The article details the research efforts of Dr. Shri Hari Prasath and colleagues to design and install a Smart Remote monitoring system, including their presentation at an international conference in 2014. To do this, we will use the Internet of Things (IoT), cloud storage, and a straightforward online site to track Solar PV power conversion units (PCUs). GPRS is used to enhance the Remote server's connectivity.

This system was built with LabVIEW and DAQ cards according to their respective descriptions in

[10]. The circuit relies on batteries, which are linked to detectors. Connecting sensors with LabVIEW DAQ software to the hardware allows this DAQ network to collect data. LabVIEW's remarkable communication and performance capacities have been on exhibit when presenting several variables in real time in the lab.

In [11], a project developed on an Android tablet presents an original architecture for an electronic system to monitor and optimize the operations of a thermal-solar power plant. This control unit is pre-set to do things like check and fix the device's operation and show any errors that may occur. It can be accessed from a PC via serial connection, as well as from Android-based mobile devices with an RS485/Eetricnet adapter and an internet-connected modem/router, serving as a remote monitoring and diagnostics tool for the facility.

Soham et al. [12] proposed using an internet-connected IoT network to monitor solar systems. Sensors pick up signals from the mobile radio network and interpret them. A GPRS module is used to transmit the information to the remote server. In an IoT application diagram, the lowest layer of sensors consists of current and voltage detectors and an irradiance measuring pyranometer. A wireless module allows the microcontroller to talk to the server. Consisting of the following elements, Second layer: plant data logging, real-time processing, and persistent storage in a database. The information obtained after processing and storage is used in the application layer. In this level, the data that has been collected, analysed, and stored is used extensively by web-based applications. A graphical user interface can speed up the decision-making process by providing insight into past choices and allowing administrators to keep tabs on plant performance in real time.

D. Saha [13] has created a brand-new renewable energy monitoring system named Renewable Energy Monitoring System (REMS). The software disseminates renewable energy power plants with the help of Raspberry Pi, remote cloud monitoring, and the Internet of Things (IoT). By integrating the San USB microcontroller, the Raspberry Pi Embedded Linux System (ELS), and the Online Web Monitor, a REMS architecture is created.

3. ROLE OF IOT IN SOLAR PV

One benefit of the IoT is that users may quickly link commonplace items like PCs, smartphones, sensors, and actuators to the internet with the help of devices like microcontrollers, transceivers, and information and network protocols. As a result, controlling and monitoring a PV system remotely via an IoT-integrated communication network is preferable to human inspection at the installation site. Table 1 displays the various uses of the Internet of Things in PV systems.

The IoT architecture is the basis of many SCADA systems deployed worldwide. In [14], an IoT-based SCADA system is implemented using a Raspberry Pi3 serving as the sensor gateway, DHTII temperature and humidity sensors collecting data, and IBM Bluemix cloud platform processing, visualizing, and managing the collected sensor data. Using an Adafruit IO IoT web server, an Arduino Nano, and a Raspberry Pi 2, our group of [13] participants exhibited our IoT-based urban climate monitoring system. Similarly, [15] created a web-based real-time electrical data measuring and control system in a hybrid wind/PV/battery system with InTouch. In [1], the authors suggest an IoT-based SCADA system that uses the Raspberry Pi3 and Intel Edison as sensor inputs, and then uses MQTT brokers in Node-Red to transmit sensor data to the AWS IoT Platform. The AWS IoT platform now features Alexa integration, enabling a wide range of monitoring and control options.

In contrast to common assumption, it wasn't until recently that researchers discovered employing a PV module in an outdoor application was fraught with danger and might lead to system dissatisfaction. When PV systems are put in the open, they must have the best possible utilization, dependability, and execution. The PV system and long-term statistics on solar irradiance are crucial to fulfilling the criteria. In order to get information on the PV system's efficiency, a cheap and easy data monitoring and collection system has been devised.

The literature review revealed the widespread implementation of wired and wireless data collections for the purposes of measuring, acquiring, and monitoring software. Microcontroller and licensed software LABVIEW for PV monitoring data collecting were made available through the existing research. Since most data gathering devices are installed close to PV installations, they must be hardwired and operated by hand. Some wireless data collecting devices need licensed software and cloud services to function. Few wireless data gathering systems employing open-access software maintain track of fewer parameters and are cheaper. If implemented, the suggested IoT-based data collecting system would eliminate these complications.

The system for gathering data is based on web-based, freely available tools. One INA 219 sensor is used in the current DAQ system to detect voltage, current, and power. In this work, we created a Wi-Fi enabled switch that can be managed using the Blynk mobile app. This WiFi toggle allows us to turn on and off the suggested data collecting system at sunrise and sunset. The primary goal of this research is to develop a streamlined and cost-effective data collecting system based on the Internet of Things that makes use of publicly available software and cloud storage.

Remote identification and control of objects improves efficiency, accuracy, and economic benefit while reducing the need for human involvement. This discovery has a wide variety of potential uses, some of which include smart cities, micro networks, and solar-powered street lamps. Innovating solar photovoltaic power generation with Internet of Things (IoT) technology can greatly improve performance, monitoring, and maintenance of the PV system. As the cost of renewable energy technology continues to decrease around the world, more money may be put toward building large-scale photovoltaic plants. Due to the massive scale of solar plant deployment, a cutting-edge system for computerizing the plant is needed, ideally one that includes remote internet-based plant monitoring via web-based interfaces.

Table 1 : Details of IoT in PV System as reported in Literature

Application in PV System	Microcontroller	Transreceiver	IOT Platform	Reference
Monitoring of Dust Accumulation	Arduino Uno	ESP8266	Think speak	[4]
Monitoring PV Power	Arduino Uno	ESP8266	Think speak	[6]
PV Array inspection	Arduino Uno	ESP8266	Think speak	[7]
PV Tracking system	Arduino Uno	Wemos D1Mini	zigbee	[8]
PV Cleaning system	Particle photon	Rasberry 9i	Think speak	[9]
PV Fault & control	Arduino Uno	ESP8266	Think speak	[10]
Remote monitoring	Arduino Uno	Wemos D1Mini	zigbee	[11]
Solar PV based home management system	Arduino Uno	ESP8266	zigbee	[12]
Intelligent Hybrid solar PV system	Arduino Uno	ESP8266	ubidots	[13]
Solar monitoring with visualization of monitored area	Arduino Uno	ESP8266	Think speak	[14]
Solar PV power conditioning unit	Arduino Uno	ESP8266	Think speak	[15]

This paper details how the suggested low-cost data gathering system for the PV system was conceived and developed. It has five NODEMCU boards, a variety of sensors (including DHT22 and PYRA300 and INA219 and anemometers and dust sensors), and a microcontroller (LM35). Systems that require human intervention and rely on manual labor. The proposed data collecting system can be managed with the help of the Wi-Fi-enabled switch. Not only can we reduce energy consumption by 58% with this strategy, but we can also reduce sensor waste. Over the course of 28 days, we subjected the proposed IoT-enabled data collecting system to extensive, rigorous testing in a wide range of situations. The data we received was satisfactory and accurate in real time. Anyone should be able to access the data that is updated by the DAQ system if it is deployed. Using the suggested DAQ system, scientists may monitor and sense the PV system in a more affordable and precise way. We also addressed how our suggestions are similar to other upcoming, efficient methods of data collecting.

4. CONCLUSION

There is an urgent need to find innovative and efficient methods of remote monitoring and control as a result of the integration of renewable energies into the electrical distribution network.

Both off-grid and grid-connected photovoltaic system components that make up the Internet of Things (IoT) are covered in detail.

Few generalizations may be formed from this massive study:

1. The Internet of Things eases the burden of having to manually collect performance data and monitor for issues at the plant site on a regular basis.
2. Using the Internet of Things will cut down on the amount of time spent in communication between humans and computers during PV system monitoring.
3. The Internet of Things makes it possible to efficiently and effectively diagnose PV system issues and determine the root causes of poor performance with minimal effort.
4. The Internet of Things makes it possible to keep track of performance data and failure data indefinitely, which may then be analysed to anticipate future power generation, money creation, etc.
5. It also keeps the photovoltaic systems from needing constant upkeep.
6. In order to access the control over the solar system located in distant areas or far from the control centre, IoT will play a significant role.

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LEARNERS' ACTIVISM ON E-LEARNING : A CASE STUDY

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ABSTRACT

IGNOU imparts meaningful learning experiences to learners at a convenient time, place, and affordable cost. The onset of the COVID-19 pandemic, immobilised the outdoor activities and forced the teacher-learners to stay away from face-to-face classroom activities. Information and communication technology (ICT) has emerged as a promising mode to acclimatise emergency and continue the teaching-learning process. In the present paper, learners' experiences regarding perceptions, accessibility, affordability, and operational skills of ICT methods have been reported. The purpose of this paper is to provide a comprehensive picture of learners who were new to the ODL system and suddenly shifted to the online learning mode during the pandemic period. The study revealed that the web-based tools and techniques continued the teaching-learning process during the pandemic. Proper planning of these strategies could provide added advantages in the teaching-learning process.

Keywords: *eLearning, ICT, IGNOU, ODL, Online learning, Pandemic, Web-enabled*

1. INTRODUCTION

Distance learning programs have risen in popularity over time as a result of their numerous options, flexibility, and potential to significantly improve education (Totaro et. al. 2005; Farajollahi and Moenikia 2010; Gaba and Li 2015; Allen and Seaman, 2017; Seaman et. al. 2018' Fidalgo et. al. 2020; Mukhtar et. al. 2020). It has grown as a powerful instrument of education in remote locations, where the people are unable to access education due to difficult geographical conditions, social and cultural taboos, and economic turmoil (Farajollahi and Moenikia 2010; Paliwal 2019). Effective student support is a qualitative indicator of designing and delivery of distance courses and ensuring the success of academic program offerings in distance mode. Rowentree (1992) has described the three phases need of student support that is-pre-program, program, and post-program support.

Evolution in the field of Information and communication technology (ICT), has provided both complications and new opportunities for the designing and implementation of distance education (Shirky, 2008; Sheeja 2012; Rahman 2014) and online or eLearning programs (Sale 2002; Derek Stockley 2003; Dogruer et. al. 2011; Rahman 2014). Furthermore, educational models are claimed to be useful for the growth and improvement of the eLearning process (Suryawanshi and Suryawanshi 2015) as well as student support (Ucar and Kumtepe 2020). Nevertheless, online teaching-learning is not a viable substitute for face-to-face classroom sessions (Naik 2021). Student

satisfaction is an extremely significant aspect of online learning as well (Horzum 2017). Increased student satisfaction with online learning would decrease the volume of dropouts and increase the magnitude of retention of students (Cole et. al. 2014; Shikha Anand 2019). Therefore, the needs and expectations of individual students are the key concern in designing distance and online programs (Ngaaso and Abbam. 2016; Caliskan et al. 2017). In addition to student satisfaction, social presence and learning environment are also unique features in designing eLearning courses (Robert 2012; Ekmekçi, 2015).

A novel coronavirus known as COVID-19 was discovered in a seafood market in Wuhan in 2019 (Huang et. al. 2020). The virus has the ability to spread with the proximity of persons (Li et. al., 2020; Paules et. al., 2020; Wang, Cheng, et. al., 2020). Due to the rapid spread of the virus around the world, Director-General World Health Organisation (WHO) declared COVID-19 a pandemic in March 2020 (WHO, 2020). According to Merriam-Webster Online Dictionary (2020), COVID-19 affects a high proportion of the population. Social distancing is a preventive measure to contain the spread of disease (Red Cross, 2020).

During the pandemic, Online learning has emerged as not only emergency teaching, but also it becomes a more sustainable and hybrid form of education to mitigate the challenges of continuing teaching-learning activities for mass students (Adedoyin and Soykan 2020; Dhawan 2020). This COVID-19 pandemic has brought out the best use of technology in education as well as new pedagogical strategies for future concerns (Amir et. al. 2020, Carey, 2020, Mathivanan et al 2021) and demonstrated the abilities of teachers and learners to acclimatize online teaching-learning in higher education and also increased awareness of digital scarcity and issues affecting learners' wellbeing (Bashir et al 2021). The technological resources and approaches that have been harnessed during the catastrophic COVID-19 period have drastically transformed the teaching-learning methodology in higher education. Hence, in addition to perceiving various dimensions to online teaching, the primary focus of online teaching needs to be on connectivism based on Bandura's constructivism theory (García-Morales et al 2021).

In India, distance education holds relevance due to its – affordability, equity, and accessibility feature (Rai T.). As a premier open university, Indira Gandhi National Open University (IGNOU) has been witnessed to tremendous growth in terms of student enrolment in recent years (IGNOU VC Report 2020). The University provides three-tier student support to its students –

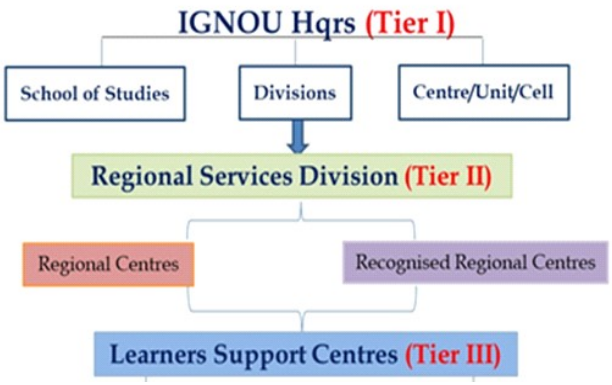

Fig. 1 : Three tier Student Support

IGNOU has taken prompt and proactive steps during the COVID-19 pandemic to continue the teaching-learning process for its learners across all 56 Regional Centres. The University optimally utilized technological instruments and techniques that enabled the learners to receive academic support. Social media platforms such as Facebook, YouTube, Twitter, Telegram, and meetings apps, such as google meet, google classroom, and zoom extensively used for –

- extending academic support to learners;
- promotional activities for enhancing outreach;
- wider publicity of new academic sessions;
- offer pre-admission counseling to prospective learners;
- conducting training and capacity buildings of part-time functionaries of Learner Support Centres;
- organizing online orientation programs for the academic counsellors;

Web-based tools and strategies are known to 21st-century learners. eLearning has been an effective and useful alternative for students during the lockdown. Having learners' opinions and perspectives on how they perceived several web-enabled methods for their studies during the pandemic when the majority of students were confined to their homes, is significant.

2. AIM AND OBJECTIVE

Keeping in view the above facts, the study has been designed to answer the following –

- Attitude, knowledge, perception of learners about eLearning techniques.
- Availability and accessibility of ICT tools and techniques for the learners.

3. METHODOLOGY

Open and distance learning system offers great flexibility in terms of access to education. In this survey-based study, 1st year learners of IGNOU, who were new in the ODL system, were invited to provide their feedback on various web-enabled teaching-learning methods to address the identified objectives. An electronic version of the questionnaire was created through the Google tool and shared with the learners in email. Responses obtained from the learners, quantified. Cross-tabulation analysis and simple statistical analytical techniques were applied for the analysis of data.

4. RESULT AND DISCUSSION

Attitude, knowledge, perception about eLearning techniques.

In the survey, learners rated the statement "Have you attended/used the following web-based 1 to 6 items for study during the pandemic" by Likert type scale as Always, Sometimes, or Never. These items areas -

i. Gyandhara (GyD), Gyandarshan (GD), Gyanvani (GV) (Web-based, Interactive Radio, and Televisions sessions),

ii. eGyankosh (a National Digital Repository),

iii. IGNOU eContent app (Mobile app),

iv. Virtual or online classes (eAcademic Counselling sessions using meeting apps),

v. Learning through social media (FB Live, YouTube streaming),

vi. iGRAM (Grievance Redress and Management web-based Grievance redressal portal).

Learners' responses have been presented Table 1. Regarding item no. i, a sizable number of learners (60%) never viewed/listened to the academic Programs which were broadcasted/ telecasted through Gyanvani, Gyandarshan, Gyandhara. Only 15% of the total respondents regularly attended. Whereas 23.8% were occasionally attended. Item numbers ii and iii dealt with the usage of eContents of self-learning materials by the learners either through a web-based repository (eGyankosh) or mobile application (eContent app) in pdf form. This accounted for more than 55 percent of the total learners. Learners appear to be comfortable with using web-based learning materials.

Regarding items *iv* and *v* nearly 30% of the total were consistent in virtual and online academic counselling sessions organized through google, zoom, WebEx platforms or through social media like Facebook (FB), YouTube, or podcast. Rests were present on occasions.

Even though the iGRAM portal was only created for learners, more than 60% of learners had never visited the portal to resolve their academic issues. Of the total 63, 26.98% sometimes found it useful to connect with the University.

Learners' knowledge and understanding of web-enabled student support resources that were available to them indicate that majority of participants were aware of IGNOU eContent app (61.9%) followed by online classes (44.44%) and eGyankosh (42.86) (table 2). Only a few learners had heard about iGRAM, as a digital inquiry or grievance redressal platform. These findings are consistent with findings of those users of web-based teaching-learning tools, wherein the majority of learners participated in online academic activities that included soft study materials, online academic sessions.

Table 1 : Learners' attitude towards uses of web-enabled teaching-learning methods

S. No.	eLearning tools	Always%	Sometimes%	Never%	Mean	SD
1.	Gyandhara, Gyandarshan, Gyanvani	15.87	23.8	60.31	0.87	0.56
2.	eGyankosh	22.22	39.68	30.09	1.29	0.67
3.	IGNOU eContent app	34.94	31.74	33.33	1.71	0.84
4.	Virtual or online classes	30.15	33.33	36.5	1.54	0.78
5.	Learning through social media	28.57	41.26	30.15	1.56	0.76
6.	iGRAM	11.11	26.98	61.9	0.71	0.47
	Mean	*23.81*	*32.79833*	*42.04667*	*1.28*	*0.68*

Table 2 : Knowledge and awareness about web-enabled tools and techniques

S. No.	Items	Frequency	%
1.	Gyandhara, Gyandarshan, Gyanvani,	16	25.40
2.	eGyankosh,	27	42.86
3.	IGNOU eContent app,	39	61.90
4.	Virtual or online classes,	28	44.44
5.	Learning through social media,	19	30.16
6.	iGRAM	10	15.87
Mean			*23.17*
SD			*10.30*

A correlation coefficient was applied between the awareness and use of digital methods for their studies as described from item *i* to *vi* in table no 1. This is a moderate positive correlation exists between awareness and uses of web-enabled student support services (R is 0.7244.).

Table 3 summarizes the learners' feedback on the usefulness and effectiveness of eLearning. Positive responses were taken into account. More than ¾ of learners (76.2%) were assimilated eContent for their study which has been available through eGyankosh or IGNOU eContent mobile app. Nearly 35% of learners found vibrant to online eCounselling sessions instead of face-to-face classes as well as submit scanned copies of assignment through digital platforms. Only 30.2% of learners revealed using iGRAM as their preferred means of resolving their queries.

In terms of the effectiveness of eLearning, 65.1 percent of 63 respondents agreed that web-based learnings were effective and useful during the pandemic and 14.29% of those disagreed with the statement. Twenty-six percent were indecisive about the relevance of eLearning.

Table 3 : Learners' feedback for the use of teaching-learning aid

S. No.	Parameters	Frequency	%
1.	Study through soft copies of study material	48	76.19
2.	Digital/online counselling sessions	36	57.1
3.	Web-enabled grievance redressal portals	19	30.16
4.	Submission of scanned hand-written assignments	35	55.56
Mean			*33.75*
SD			*11.87*

Table 4 : **Learners' perception towards uses of web-enabled teaching-learning methods**

S. No.	Scale	Frequency	%
1.	Agree	41	65.1
2.	Disagree	9	14.3
3.	No idea	13	20.6
	Total	63	

Availability and Accessibility of ICT tools and techniques

Infrastructure accessibility and affordability, including having digital devices, high-speed internet connectivity, as well as knowledge of how to use these web-based resources, are important aspects. Learners were asked to provide information on the accessibility of the internet, the availability of required devices, and knowledge and functional skills of various information and communication techniques (ICT). Of the 63, 73% of learners were having laptop/desktop or mobile phones for eLearning. The use of web-based techniques was convenient for 49.21% of learners. Merely 34.92 percent of learners, on the other hand, were having proficiency in online learning. It implies that, despite their limited knowledge of ICT, learners attempted to use tech-mediated resources and techniques in their studies (Table-5).

Table 5 : Learners' response on availability and accessibility ICT tools

S. No.	Parameters	Frequency	%
1.	Easy access of high-speed internet facility	29	46.03
2.	Having laptop/desktop, or mobile for eLearning	46	73.02
3.	Comfortable in using internet and ICT tools for study	31	49.21
4.	Having sufficient understanding about ICT tools and techniques	22	34.92
Mean			*32*
SD			*10.10*

Distance learning courses offer significant differences from the classic classroom environment (Totaro *et al* 2005). Student support services are crucial in distance education. IGNOU provides a wide range of support services during pre-admission, after admission, and post-completion of the academic program. These support services are academic, administrative, and general in nature. Even academic support in terms of organizing counseling sessions may also vary depending on the structure of the curriculum and level of the program. Efficient support services are strongly and positively linked to academic success (Farajollahi and Moenikia 2010).

Although teaching-learning tools such as *Gyanvani, Gyandhara, Gyandarshan,* as well as digital grievance redressal portal (iGRAM) are already in place for quite some time. Learners seem to be less familiar with these tools. They did not use them, nor did they comprehend the utility of these programs. It appears that the academic programs organized by *Gyandhara, Gyandarshan,* or *Gyanvani* may be the less popular among the learners. There is a need to increase student awareness of the *Gyandarshan* and *Gyanvani* programs. However, the use of social media and app-based online classes were found to be remedial and substitute during the lockdown. This gets the support from the study wherein the use of ICT in student support has been assumed a powerful strategy for providing learner-centered services in ODL (Jung, 2007). Furthermore, with the development of ICT, ODL institutions can offer individualized and interactive student support services faster and easier than ever such as telephone or email help desks, eCounseling, e-tutoring, and tutoring sessions via video-conferencing (Jung, 2007). However, some external and internal constraints may influence eLearning activities. The external factors such as interrupted internet connectivity paid internet supply, and internal factors like time management, distraction while learning online for a longer period were found to be challenged by the students in online learning (Amir *et. al.* 2020). In this study too, learners reported the constraints of either access or use of ICT tools. Analysis of data revealed that a mean of 43% of learners never used the web-based methods as mentioned in table 1. This may be due to a lack of knowledge, enthusiasm, motivation infrastructure, and internet connectivity. Paliwal (2019) reported the lack of sufficient ICT infrastructure and poor net connectivity, interrupted supply of electricity in the hilly regions influenced the tech-based teaching-learning activities in the hill region.

Distance education has substantially improved because of new information and communication technology, and online peer learning strategies have been found to promote academic accomplishment (Razak and See 2010). Learning behaviors of learners have increased during COVID-19 (Jamalpur *et. al.*; 2021). Online learning gives learners a chance to be innovative by using computer technology. However, the majority of the learners preferred face-to-face learning in terms of social presence, social interaction, and satisfaction (Bali and Liu 2018). Tait (2014) explained that digitalization brought some challenges for students' support in the online learning environment. Students' attitudes and perceptions of eLearning were found to be responsive in this study. It is consistent with findings of a study conducted by Amir *et. al.* (2020), that the sudden closure of the university globally due to the COVID-19 pandemic, albeit undesirable, presents an enormous opportunity for cultural transformation in the education system. This created big opportunities for tech-savvy generations. Pandemic phased has delivered a significant message for everyone to live with and endure the crisis and also adopt the digital world for higher education.

Now is a time to ensure the availability of reliable communication tools, high-quality digital academic experiences, and promote technology-enabled learning for students to bridge the gaps that existed in the education system before and after the COVID-19 disaster, which is also inevitably required for uninterrupted learning. Following the pandemic, the initiative should be taken to build a curriculum that reflects the perceptible shift in students' topic knowledge and learning experiences, as well as enabling them to think critically (Mishra *et al* 2020, Basheer et al 2021).

Online teaching-learnings have perceived exponential growth due to suddenly imposed lockdown to contain the spread of the pandemic. eLearning is also a unique way of learning in terms of its eco-friendly nature because it promotes paperless learning (Ghosh S). ODL institutions have the scope to make the eLearning components an essential part of the teaching-learning process. There is a need to motivate learners about the value of eLearnings and to spread the word about these methods to a large number of learners. ICT tools should be included judicially as an integral part of teaching and assessment activities. Repeated studies would be quite advantageous in achieving consistency in learners' responses.

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STUDIES ON UNCONFINED COMPRESSIVE STRENGTH OF CHEMICALLY TREATED BIO-ENZYMATIC SOIL

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ABSTRACT

To achieve the necessary engineering features, soil stabilization involves mechanical or chemical modification of one or maybe more soil properties. The purpose of present study was investigating soil improvement using traditional and non - traditional materials. The commercially available bio - enzyme (DZ-2X), which is a completely natural bio-degradable product, was used to enhance the properties of locally available soil along with optimum dosages of chemical admixtures such as lime and micro-silica. In the preliminary stage, the interaction of bio-enzyme was studied by evaluating the variation in properties of soil with respect to various dosages and curing period to obtain the optimum dosage of bio-enzyme. Further, chemical treatment was provided with optimum doses of lime (8 %) and micro silica (7 %) to further enhance the performance of enzyme stabilized soil. The test results shows maximum improvement in unconfined compressive strength (UCS) for dosages of 1000 ml/6 m^3 of DZ-2X. The combined effect of all constituent materials also shows an increase in UCS of soil.

Keywords: *UCS, Black Cotton Soil, DZ - 2X, Lime, Micro-Silica*

1. INTRODUCTION

Soil stabilisation is the process of altering a soil's characteristics to make it appropriate for use as a foundation material in any engineering project. In other words, ground improvement refers to altering the foundation's soil in order to improve its performance under various conditions. Chauhan *et al* (2016) [1] conducted experimental research to determine the effect of Geogrid and several stabilisers viz; micro silica, flyash, and lime on geotechnical aspects of black cotton soil. The effect on strength (CBR, UCS) on the natural soil was treated with various quantities of stabilising agents. Three group A, B, C were considered to conduct the experimental investigations and to determine the optimal proportions of fly ash, micro silica, & lime. In group A, natural soil was treated with micro silica, fly ash, and lime in varied amounts viz; 0, 2.5, 5, 7.5, 10, 15, and 20 %, and 0, 3, 6, 9, 12, and 15% and 0, 3, 6 and 9 %, respectively. In group B, the natural soil was treated at optimum percentages obtained from the results in group optimal proportions of micro silica, fly ash & lime to stabilize black cotton soil have been observed as 5%, 3% & 3% correspondingly. Ghavamshirazi *et al* (2020) [2]

carried out the laboratory investigations to check the suitability of industrial waste (Micro Silica) to improve the volume change and strength behaviour of clayey soil (CH) along with lime. Laboratory observations were made by treating the clay of high plasticity (CH) with lime alone (3% and 5%), Micro Silica alone (10% and 20%) and mixtures of lime and Micro Silica (3–10%, 5–10%, 3–20% and 5–20%). The variation in swell potential and UCS value of high plasticity clay for different combination lime and micro silica was found. Safana *et al* (2017) [3] examined effect of Terrazyme (Bio- enzyme) on characteristics of lateritic soil, which was collected from Ernakulum district.

The preliminary tests (Atterberg limits, Compaction Test and Sieve Analysis) had been performed for identifying soil type and clay content. The laboratory investigation had performed by treatment of natural soil with different doses of Terrazyme for determining unconfined compressive strength (UCS) & California Bearing Ratio (CBR) of lateritic soil. Further, impact of curing period upon CBR value of stabilized soil was also checked for 7, 14 and 28 days. The results of stabilized soil were compared with un-stabilized soil. From the experimental observations, after 28 days of curing, the soil's UCS & CBR values were found to be 281.5 % and 139.32 % higher, correspondingly, than those of natural soil. V. Vasiya *et al* [4] (2021) conducted experimental investigations on black cotton soil. Conversely, treated soil had a shear parameter improvement of 1.5 times relative to untreated soil in terms of both friction angle and cohesion angle. The MDD at 24% OMC in untreated soil was 15.58 kN/m^3. At 20% OMC, MDD produced by 2% Terrazyme was 16.47 kN/m^3. The present study focuses on UCS of black cotton soil treated with DZ-2X, lime and micro silica.

2. MATERIALS USED FOR EXPERIMENTAL TESTING PROGRAMME

2.2.1 Black Cotton Soil

The black cotton soil was collected from Government College of Engineering Amravati, Maharashtra, India for complete detailed experimental investigation.

2.2.2 Bio - Enzyme

The commercially available Bio – Enzyme (DZ - 2X) was selected for the present study which was produced by Dhara Biotech, Sarsa, Gujarat, India.

2.2.3 Lime

The locally accessible hydraulic lime was utilized for research work.

2.2.4 Micro – Silica

The micro - silica provided by Nakoda Enterprises, Indore, Madhya Pradesh (Indiamart) was used for present study.

3. METHODOLOGY

The different dosages of DZ-2X selected for experimental investigation are described in Table 1. The dosages of DZ-2X used for soil treatment were selected based on previous research work and data provided by suppliers. For DZ - 2X, the dosages for treatment selected were 1000 ml for 9 m^3, 8 m^3, 7 m^3, 6 m^3 and 5 m^3 with respect to maximum dry density (MDD). The optimum percentage of DZ-2X content was found out as 0.106 ml/kg of soil. Further in addition to the optimum content of DZ-2X, lime and micro silica treatment to soil was given at their optimum percentages obtained from laboratory test results for improving strength characteristics of soil. The various laboratory tests were performed on untreated soil and classify the soil as CH with unconfined compressive strength as 127.03 kN/m^2.

4. RESULTS AND DISCUSSIONS

4.1 Effect of Bio-Enzyme on Compaction Characteristic of Soil

The compaction tests were carried out for determining OMC and MDD. The OMC and MDD for soil treating by several varying dosages of DZ-2X are shown in Table 2. The reduction OMC and increase in MDD was observed for treated soil samples.

Table 2: OMC and MDD of Soil Treated with Various Percentages of Bio - Enzyme

Sr. No.	Dosage of DZ - 2X	Quantity (ml/kg)
1	D1 DZ (1000ml for 9 m3)	0.076
2	D2 DZ (1000ml for 8 m3)	0.086
3	D3 DZ (1000ml for 7 m3)	0.098
4	D4 DZ (1000ml for 6 m3)	0.106
5	D5 DZ (1000ml for 5 m3)	0.128

4.2 Effect of Bio - Enzyme on Unconfined Compression Strength

The unconfined compression tests were carried out on black cotton soil treated with various dosage of bio-enzyme. The samples of treated soil had been kept for various curing periods viz; 1, 7, 14, 21 and 28 days. Figure 1 to Figure 5 shows the stress strain curves for 0.076 ml/kg, 0.086 ml/kg, 0.098 ml/kg, 0.106 ml/kg, and 0.128 ml/kg dosages respectively. The recorded UCS values are shown in Table 3.

Table 3: UCS Values of Expansive Soil Treated with Bio – Enzyme (DZ -2X)

Sr. No.	Dosage of DZ - 2X	Dosage (ml/kg)	Curing Period in Days				
			1	7	14	21	28
			UCS (kN/m^2)				
1	D1 DZ	0.076	178.14	174.61	219.89	236.71	219.89
2	D2 DZ	0.086	185.31	208.49	224.29	245.78	250.02
3	D3 DZ	0.098	191.36	222.33	241.78	264.75	270.46
4	D4 DZ	0.106	218.8	249.2	267.02	289.7	325.12
5	D5 DZ	0.128	219.42	254.1	276.89	290.45	334.87

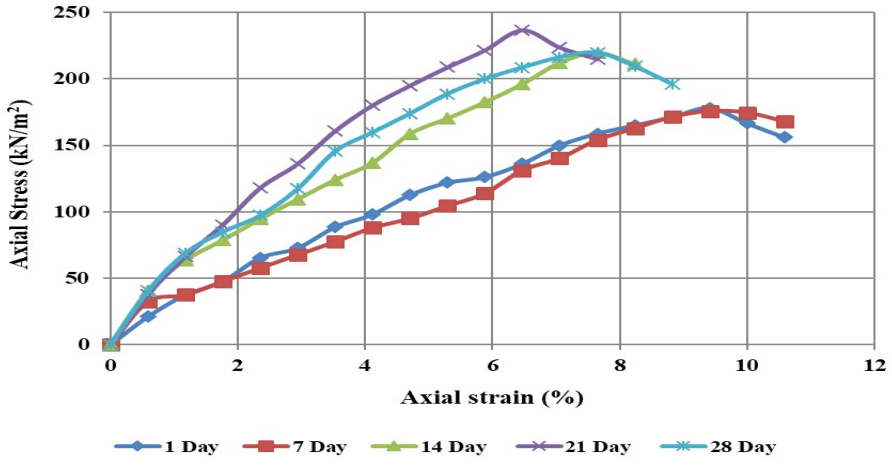

Fig.1: Stress Strain Curves for D1 DZ (1000 ml for 9 m^3) with Varying Curing Period

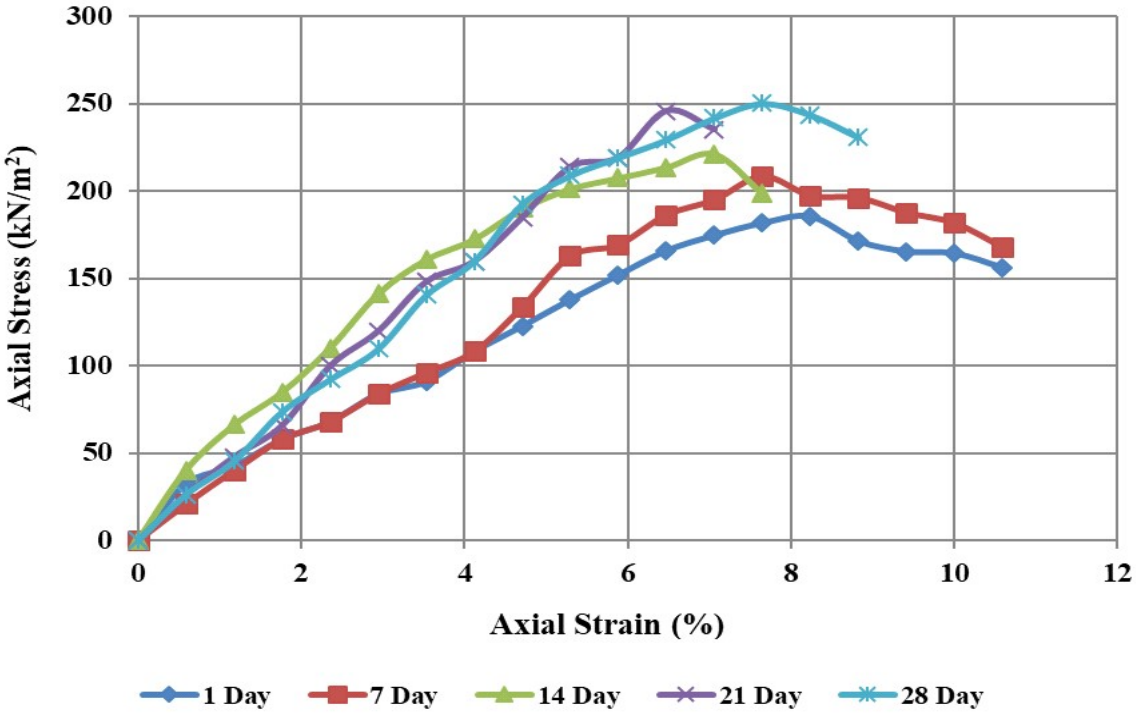

Fig.2: Stress Strain Curves for D2 DZ (1000 ml for 8 m³) with Varying Curing Period

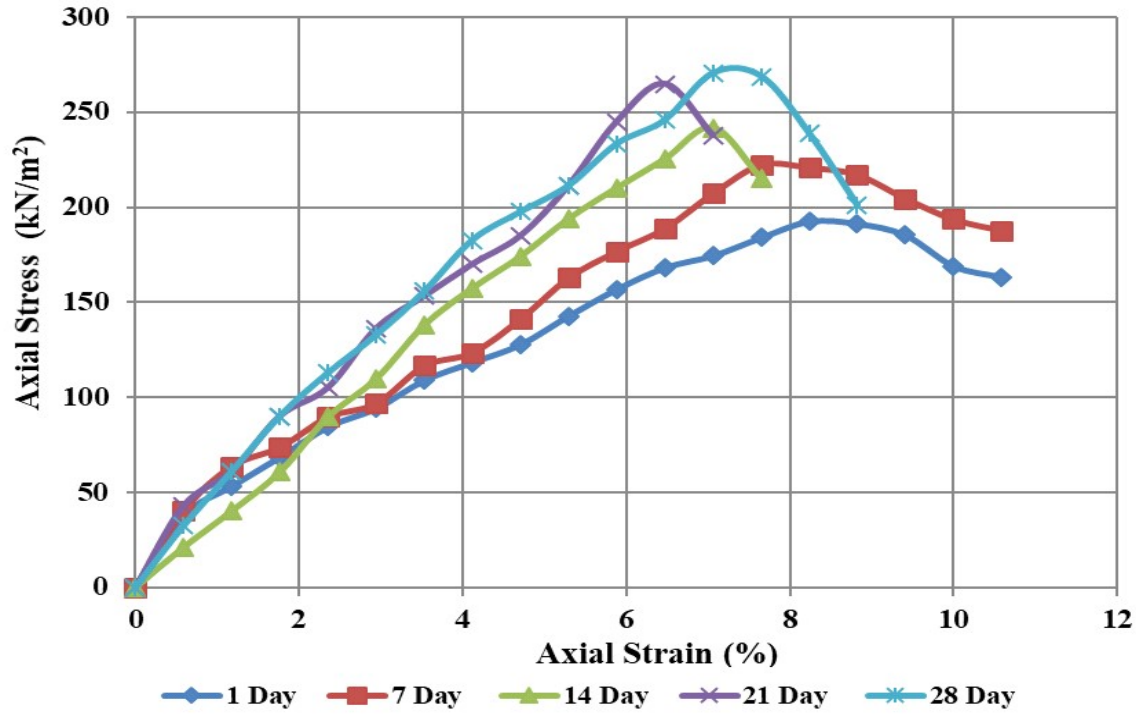

Fig.3: Stress Strain Curves for D3 DZ (1000 ml for 7 m³) with Varying Curing Period

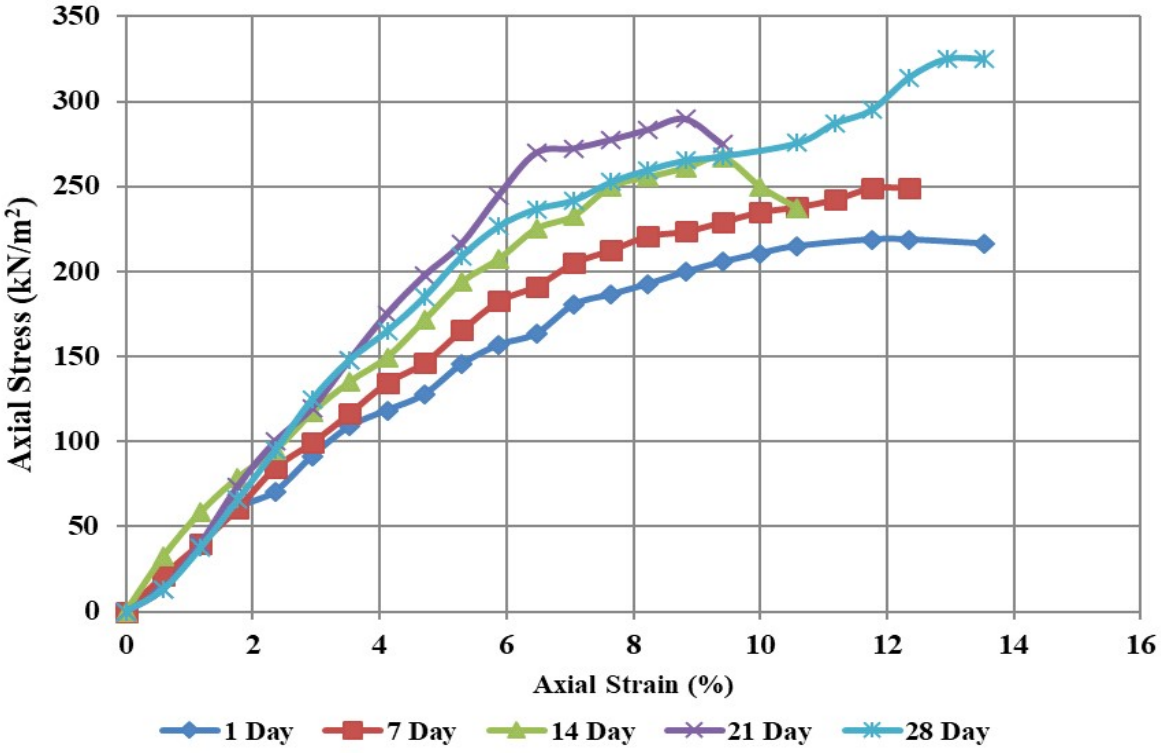

Fig. 4: Stress Strain Curves for D4 DZ (1000 ml for 6 m³) with Varying Curing Period

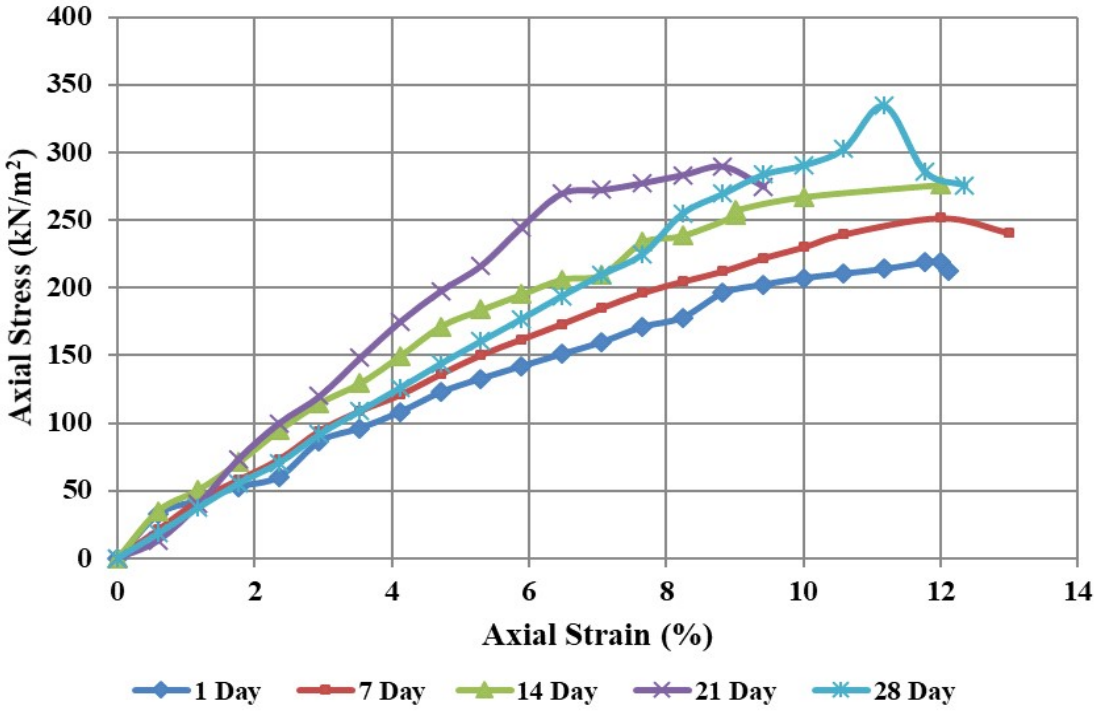

Fig. 5: Stress Strain Curves for D5 DZ (1000 ml for 5 m³) with Varying Curing Period

The variation of UCS of soil treated with bio-enzyme with respect to curing period is presented in Figure 6.

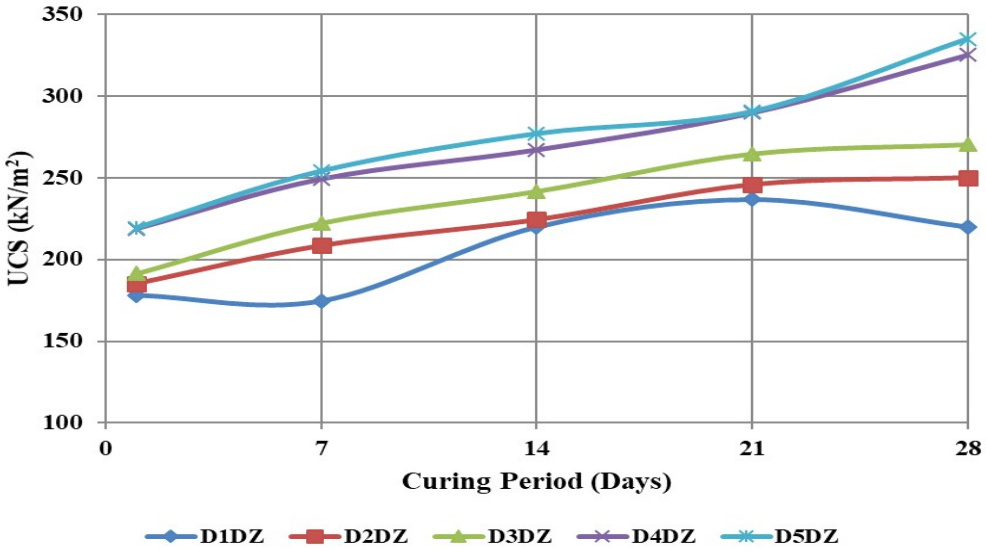

Fig. 6: Variation in UCS of Soil Treated with Bio-Enzyme with Varying Curing Period

It was observed that UCS of soil treated with bio - enzyme increases with increase in curing period. The variation of UCS of soil treated with bio - enzyme with respect to dosages of DZ-2X is presented in Figure 7. It was also observed that there is an increase in UCS for a dosage of 0.106 ml/kg. The marginal increase was observed with further increase in dosage of DZ - 2X. Thus, 0.106 ml/kg was considered as optimum dose for further experimental investigations.

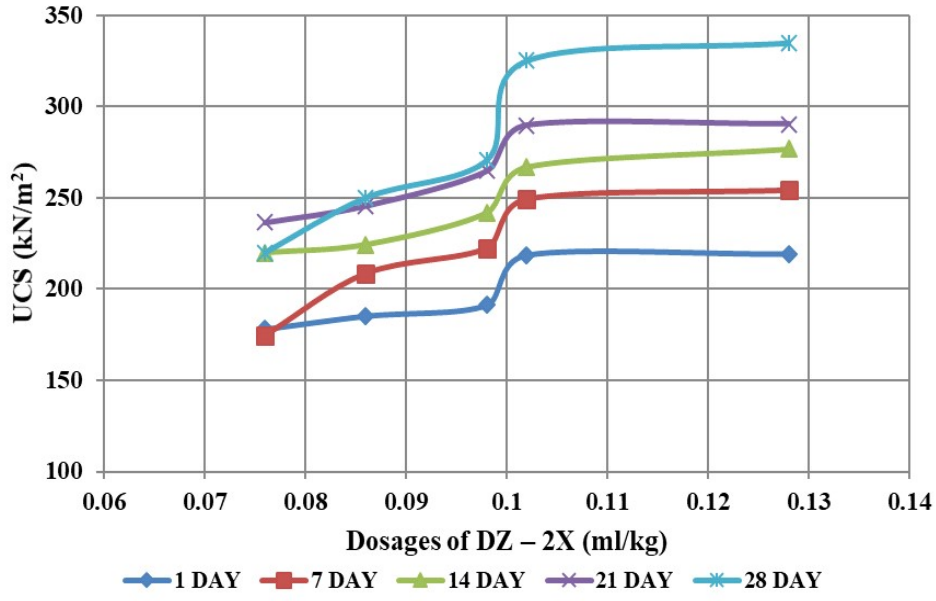

Fig. 7: Variation of UCS of soil with respect to dosage of DZ - 2X

4.3 Effect of Stabilization of Soil Treated with Lime and Bio - Enzyme on UCS

The UCS tests have been performed upon soil sample treated with bio-enzyme (DZ-2X) along with lime. From the previous results of experimental investigations, optimum % of lime and bio-enzyme doses of 6 m^3 (D4DZ) i.e. 0.106 ml/kg and 8 % lime were considered. Figure 8 shows the stress vs strain graphs for UCS test treated with lime and DZ-2X for various curing period viz; 1, 7, 14, 21, 28 days. Table 4 shows value of UCS soil treated with bio-enzyme and lime.

4.4 Effect of stabilization of soil treated with enzyme and Micro-Silica on UCS

The UCS tests have been performed on soil samples treated with bio-enzyme (DZ-2X) along with micro silica. From the previous results of experimental investigations, optimum percentages of micro silica and bio-enzyme doses of 6 m^3 (D4DZ) i.e. 0.106 ml/kg and 7 % micro silica were considered.

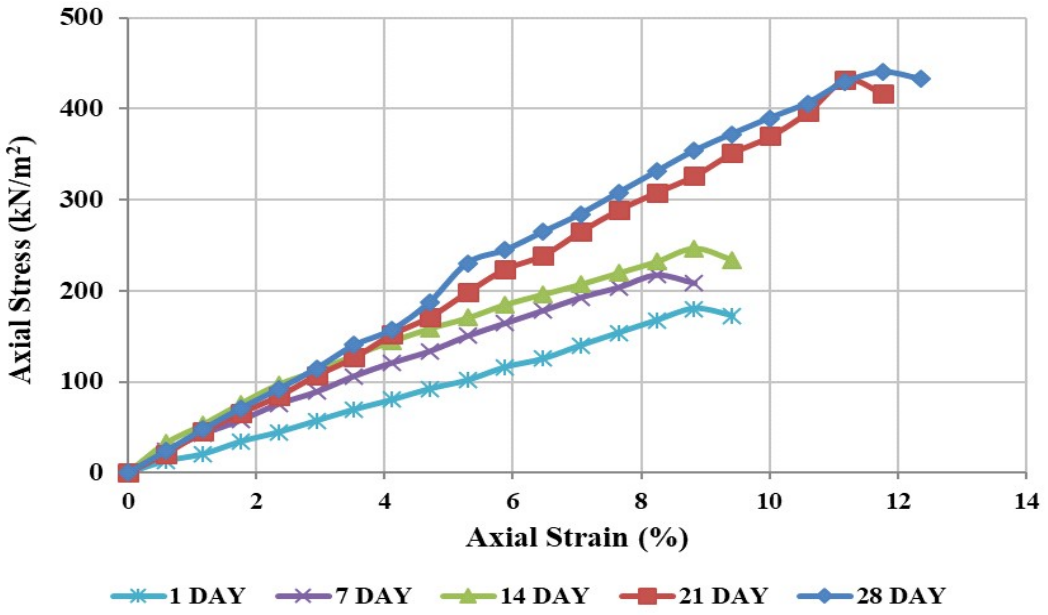

Fig. 8: Stress vs Strain Curves for UCS Test Treated with Lime and DZ - 2X

Table 4: Results of UCS Test on Soil Treated with Lime and Bio-Enzyme

Type of Stabilizers	Curing Period in Days				
	1	7	14	21	28
	UCS (kN/m^2)				
Soil + DZ-2X (6m^3) + Lime (8 %)	180	217	246	432	440
% Increase	41.73	70.86	93.70	240.15	246.45

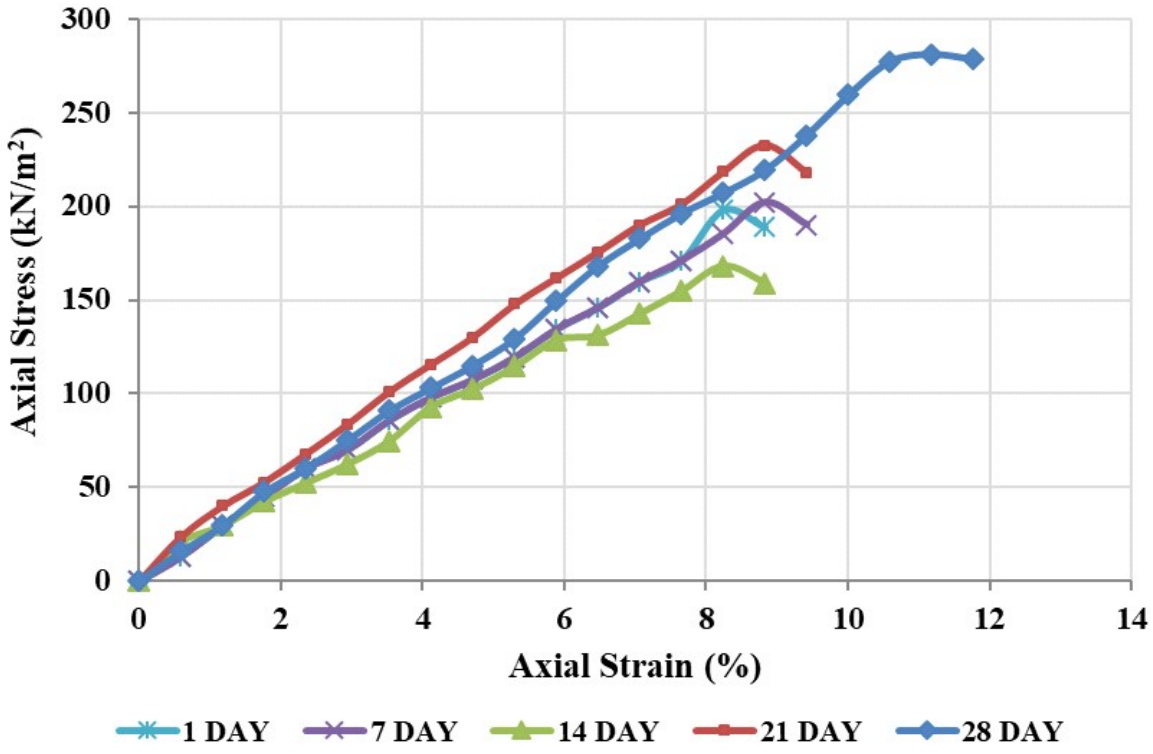

Fig. 9: Stress vs Strain Curves for UCS Test Treated with Micro - Silica and DZ - 2X

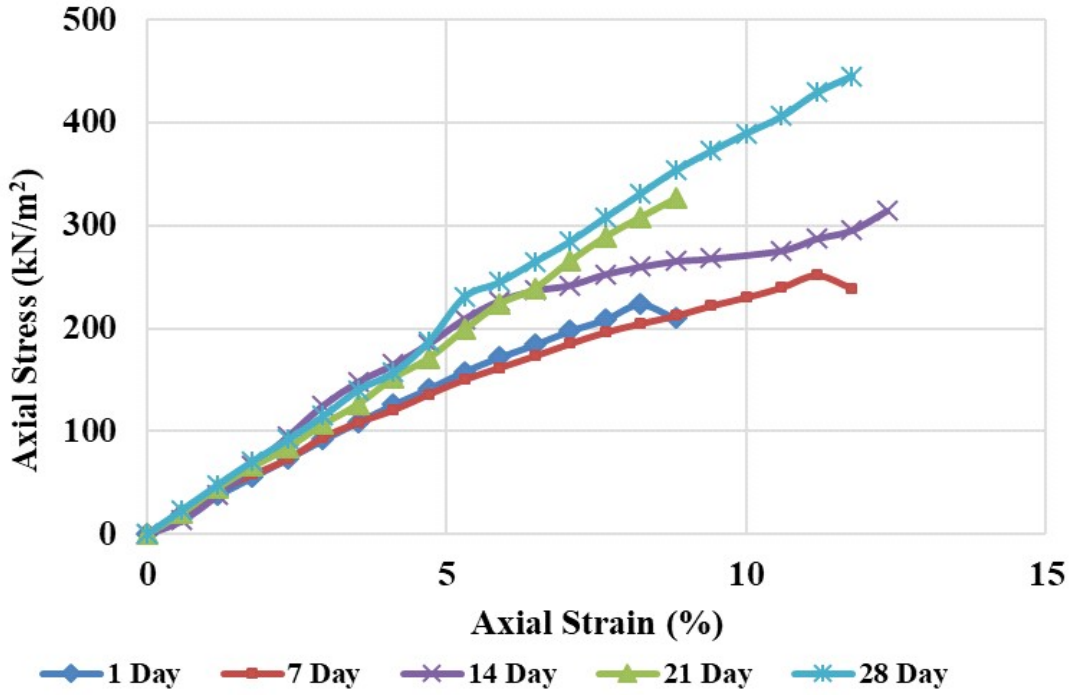

Fig. 10: Stress vs Strain Curves for UCS Test Treated with Micro – Silica, Lime and DZ - 2X

Table 5: Results of UCS Test on Soil Treated with Micro - Silica and Bio-Enzyme

Type of Stabilizers	Curing Period in Days				
	1	7	14	21	28
	UCS (kN/m^2)				
Soil + DZ-2X (6m^3) + Micro – Silica (7 %)	198	202	168	232	281
% Increase	55.90	59.05	32.28	82.67	121.25

Table 5 shows values of UCS for various curing period when treated with micro silica and bio-enzyme. Figure 9 shows the Stress vs strain graphs for UCS of soil treated with optimum doses of bio-enzyme and micro-silica.

Table 6: Results of UCS Test on Soil Treated with Micro-Silica, Lime and Bio-enzyme

Type of Stabilizers	Curing Period in Days				
	1	7	14	21	28
	UCS (kN/m^2)				
Soil + DZ-2X (6m^3) + + Lime (8 %) +Micro – Silica (7 %)	223	250	326	315	445
% Increase	75.59	96.85	156.69	148.03	250.39

5. CONCLUSION

5.1 Compaction Characteristics of Stabilized Soil

1. After treating the soil with bio-enzyme, the OMC of treated soil decreased from 23.5 % to 20.2%.
2. Results for OMC and MDD were observed for stabilization with D4DZ (1000 ml for 6 m^3) and the values of OMC and MDD were 20.5 % and 15.6 kN/m^3 respectively.

5.2 Unconfined Compression Strength Characteristics of Stabilized Soil

1. UCS value of stabilized soil increases up-to 156 % when treated with optimum dose of bio-enzyme (DZ2X) i.e., 0.106 ml/kg as compared to untreated soil sample after 28 days of curing.
2. UCS value increases up-to 246 % when treated with optimum doses of bio-enzyme (DZ2X) and lime i.e., 0.106 ml/kg and 8 % as compared to untreated soil sample after 28 days of curing.
3. UCS value increases up-to 121 % when treated with optimum doses of bio-enzyme (DZ2X) i.e., 0.106 ml/kg and micro silica i.e., 7 % as compared to untreated soil sample after 28 days of curing.
4. UCS value increases up-to 250 % when treated with optimum doses of bio-enzyme (DZ2X), lime and micro silica i.e., 0.106 ml/

kg, 8 % and 7 % as compared to untreated soil sample after 28 days of curing.

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QSPR ANALYSIS OF ANTIBIOTICS USED TO TREAT TUBERCULOSIS USING TOPOLOGICAL INDICES

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ABSTRACT

QSPR analysis is a promising approach for correlating the properties of chemicals with its structural features using graph theoretical concept 'Topological Index'. In this article, some antibiotics used for the medication of tuberculosis are examined using degree based topological indices. For the investigation, statistical parameters are utilized. In this article, QSPR analysis using topological indices show significant predictive capacity for the considered physical properties of antituberculosis drugs.

Keywords*: Antituberculosis drugs, QSPR analysis, topological indices.*

1. INTRODUCTION

World has witnessed different forms of epidemics. The one very well-known epidemic is tuberculosis (TB). Mycobacterium tuberculosis is the bacterium responsible for TB. It attacks various parts of body like lungs, brain, spine, kidney and others. It is a contagious disease. Serious diseases like TB that pervaded earlier in the world have been eliminated to a considerable extent with the invention of vaccinations like antibiotics. Antibiotics play a pivotal role in the treatment of TB. The regular treatment of TB includes use of antibiotics like isoniazid, rifampin, pyrazinamide, ethambutol and other drugs. Bedaquiline is a new form of drug added to this list. These and other drugs are used for research in various fields.

A chemical structure converted in the form of a graph by labelling its atoms as vertices and bonds as edges is referred to as a molecular graph. Graph theory and chemistry are two different subjects combined for the origination of a new branch called chemical graph theory. Particularly, in this subject molecules are mathematically modelled to study the physical properties of the chemical structures. Physical properties like molecular weight (MW), boiling point (BP) and many such properties of the chemical compound are directly associated to its chemical structure. These properties are modelled

with the use of topological indices. Topological index (TI) is a single number computed from a molecular graph to characterize its underlying property. They are defined in two forms distance based and degree based. The first TI defined was Wiener index by Wiener [12]. The oldest degree-based TI's were defined by Gutman and Trinajstiæ [5, 6] and named as Zagreb indices.

The first Zagreb index is

$$M_1(G) = \sum_{u \in V(G)} d_G(u)^2$$

and second Zagreb index is

$$R(G) = \sum_{uv \in E(G)} \frac{1}{\sqrt{d_G(u) d_G(v)}}.$$

Another popular degree based TI is Randić index given by Randić [10] in 1975 as

$$R(G) = \sum_{uv \in E(G)} \frac{1}{\sqrt{d_G(u) d_G(v)}}.$$

Due to enlarged applications of TI's it has gained a wide acceptance in the research field of molecular structures. An inexpensive tool to perform the analysis of chemical structures to relate with their physical properties is quantitative structure property relationship (QSPR). It gives an insight to develop quantitative relation between chemical structures and their properties. The earliest QSPR analysis was conducted by Wiener in 1947 to analyse the BP of alkanes [12]. Some of the recent QSPR analysis to mention are by Mondal et al. [9] to study neighbourhood degree based topological descriptors. One more to refer is by Kumar et al. [8] based on analysis of alkanes using some degree based topological indices. Abundant research work is available in this field [1, 12].

In the present article, QSPR analysis is investigated for some antibiotics used to treat TB. A graph *G*, having vertex set *V*(*G*) and edge set *E*(*G*) is used [7]. The number of vertices adjacent to a vertex *v* in *G* is its degree $d_G(v)$. The notion of degree in graph theory is associated to valence concept of chemistry.

2. TOPOLOGICAL INDICES

Topological indices utilized for the analysis are given below.

Redefined version of Zagreb indices is defined by Ranjini et al. [11] as follows.

First redefined Zagreb index is

$$ReZG_1(G) = \sum_{uv \in E(G)} \frac{d_G(u) + d_G(v)}{d_G(u) d_G(v)}$$

Second redefined Zagreb index is

$$ReZG_2(G) = \sum_{uv \in E(G)} \frac{d_G(u) d_G(v)}{d_G(u) + d_G(v)}.$$

Third redefined Zagreb index is

$$ReZG_3(G) = \sum_{uv \in E(G)} (d_G(u) d_G(v)) \left(d_G(u) + d_G(v)\right)$$

Inverse Randic index is proposed by Bollobas et al. [2, 4] as

$$RR(G) = \sum_{uv \in E(G)} \sqrt{d_G(u) d_G(v)}.$$

Augmented Zagreb index is defined by Furtula et al. [3] as

$$AZI(G) = \sum_{uv \in E(G)} \left(\frac{d_G(u) d_G(v)}{d_G(u) + d_G(v) - 2} \right)^3.$$

3. DATA SOURCE

The data source of 13 antibiotics used as therapeutics for TB are referred from [1,13]. Some physical properties considered for analysis are molecular weight (MW), boiling point (BP), flash point (FP), enthalpy of vaporization (EV), molar refractivity (MR), polarizability (P) and molar volume (MV).

4. METHODOLOGY

The molecular graphs of chemical structures are drawn including hydrogen suppression. Linear regression analysis and plots are determined by applying R-software.

3. RESULTS AND DISCUSSION

For the regression analysis the linear model used is $P_p = a + (TI)b$. P_p is the physical property of a drug, *the* y-intercept, *TI* refers topological index and *b* is the slope. The QSPR analysis is conducted for seven physical properties of antibiotics used to treat tuberculosis using five degree based topological indices.

M represents the sample size. Statistical parameters used for investigation are correlation coefficient (*r*). adjusted r^2 gives the percentage of variance of dependent variable with respect to the independent variable. A *p*-value is statistically used to validate the deviation between the calculated value and reference value. Lower the *p*-value (< 0.05), more is the statistical significance. Correlation coefficient (*r*) is one of the statistical parameters to establish a linear relationship between two variables. It ranges from -1 to 1. The relation is significant if the *r* value nears to -1 or 1. *F* is the Fisher statistic test value that indicates the regression model to be a better fit statistically.

For analysis purpose 13 antibiotics are used and their details are entered in Table 1. The calculated TI's values are recorded in Table 2. Computed statistical parameters of the linear model for properties of antibiotics used to treat TB against the considered topological indices are specified in Tables 3 to 7. Correlation coefficient (*r*) values are placed in Table 8. Figure 1 to 5 shows the plot of physical properties of antituberculosis drugs against TI's.

Table 1: Properties for antituberculosis drugs

Name of medicine	MW	BP	FP	EV	MR	P	MV
Amikacin	585.6	981.8	547.6	162.2	134.9	53.5	363.9
Bedaquiline	555.5	702.7	378.8	108	156.2	61.9	420.1
Clofazimine	473.4	566.9	296.7	85.1	136.2	54	366.1
Delamanid	534.5	653.7	349.1	96.3	127.7	50.6	368
Ethambutol	204.31	345.3	113.7	68.3	58.6	23.2	207
Ethionamide	166.25	247.9	103.7	46.5	49	19.4	142
Isoniazid	137.14	251.97	251	-	36.9	14.6	110.2
Levofloxacin	361.4	571.5	299.4	90.1	91.1	36.1	244
Linezolid	337.35	585.5	307.9	87.5	83	32.9	259
Moxifloxacin	401.4	636	338.7	98.8	101.8	40.4	285
p-Aminosalicyclic acid	153.14	380.8	184.1	66.3	39.3	15.6	102.7
Pyrazinamide	123.11	173.3	119.1	54.1	31.9	12.6	87.7
Rifampin	822.9	937.4	561.3	153.5	213.1	84.5	611.7

Table 2 : Calculated topological indices values

Name of medicine	$ReZG_1(G)$	$ReZG_2(G)$	$ReZG_3(G)$	$RR(G)$	$AZI(G)$
Amikacin	40	49.5	1306	99.3054	304.2969
Bedaquiline	37	47.68	1258	97.5588	389.7363
Clofazimine	31.67	42.25	1072	86.1859	324.8437
Delamanid	38	47.9333	1230	99.6666	314.4032
Ethambutol	14	12.8666	252	26.353	104
Ethionamide	11.6667	11.1667	258	23.5899	72.8906
Isoniazid	10	10.5167	226	21.4947	78.7656
Levofloxacin	26	34.5	1032	70.8872	124.25
Linezolid	23	28.4	704	58.3221	195.0625
Moxifloxacin	27	35.6167	984	73.0188	267.6564
p-Aminosalicyclic acid	11	11.8	292	24.7261	76.2812
Pyrazinamide	9	9.4	202	19.3631	66.1406
Rifampin	50.3334	61.3857	2660	33.9435	863.9118

Table 3: Statistical parameters of the linear model for properties of antituberculosis drugs against $ReZG_1(G)$

Properties	M	a	b	r	r^2	F	p
MW	13	-25.9227	15.8000	0.9949	0.9889	1065	2.663e-12
BP	13	95.886	17.611	0.9421	0.8774	86.9	1.484e-06
FP	13	45.604	9.913	0.9111	0.8147	53.76	1.481e-05
EV	12	29.9303	2.3772	0.8942	0.7795	39.88	8.736e-05
MR	13	-3.0155	3.9520	0.9772	0.9509	233.3	9.411e-09
P	13	-1.2243	1.5676	0.9773	0.951	233.7	9.342e-09
MV	13	1.3658	10.8000	0.9680	0.9314	163.9	5.96e-08

Table 4: Statistical parameters of the linear model for properties of antituberculosis drugs against $ReZG_2(G)$

Properties	M	a	b	r	r^2	F	p
MW	13	12.345	11.651	0.9842	0.9659	340.9	1.257e-09
BP	13	136.871	13.040	0.9359	0.8647	77.71	2.567e-06
FP	13	68.522	7.345	0.9057	0.804	50.23	2.025e-05
EV	12	36.4793	1.7298	0.8730	0.7384	32.05	0.00020
MR	13	6.3494	2.9209	0.9690	0.9334	169.2	5.053e-08
P	13	2.4895	1.1586	0.9691	0.9335	169.5	5.006e-08
MV	13	28.8982	7.9196	0.9524	0.8986	107.3	5.194e-07

Table 5: Statistical parameters of the linear model for properties of antituberculosis drugs against $ReZG_3(G)$

Properties	M	a	b	r	r^2	F	p
MW	13	106.9035	0.3020	0.9689	0.9333	169	5.085e-08
BP	13	257.2179	0.3216	0.8766	0.7474	36.5	8.407e-05
FP	13	129.6528	0.1887	0.8836	0.7609	39.18	6.175e-05
EV	12	52.0829	0.0437	0.8531	0.7005	26.73	0.00041
MR	13	29.6119	0.0762	0.9603	0.9151	130.3	1.942e-07
P	13	11.7163	0.0302	0.9604	0.9152	130.5	1.923e-07
MV	13	89.1597	0.2099	0.9583	0.911	123.9	2.514e-07

Table 6: Statistical parameters of the linear model for properties of antituberculosis drugs against *RR*(*G*)

Properties	M	a	b	r	r^2	F	p
MW	13	140.520	4.125	0.6268	0.3377	7.119	0.02187
BP	13	239.365	5.342	0.6897	0.428	9.978	0.0091
FP	13	143.377	2.706	0.6002	0.3021	6.194	0.03011
EV	12	58.3858	0.5836	0.5332	0.2127	3.972	0.0742
MR	13	39.8646	1.0096	0.6025	0.3051	6.269	0.0293
P	13	15.7840	0.4005	0.6025	0.3051	6.27	0.0293
MV	13	128.562	2.582	0.5585	0.2494	4.987	0.0473

Table 7: Statistical parameters of the linear model for properties of antituberculosis drugs against *AZI*(*G*)

Properties	M	a	b	r	r^2	F	p
MW	13	151.3584	0.9076	0.9214	0.8352	61.82	7.698e-06
BP	13	319.3783	0.9059	0.7813	0.5751	17.24	0.0016
FP	13	163.3253	0.5430	0.8045	0.6152	20.19	0.0009
EV	12	61.2019	0.1232	0.7729	0.5571	14.84	0.0032
MR	13	39.5313	0.2344	0.9343	0.8613	75.54	2.945e-06
P	13	15.65188	0.09296	0.9343	0.8614	75.59	2.936e-06
MV	13	114.20605	0.65448	0.9458	0.8849	93.24	1.048e-06

Table 8: Correlation coefficient (r) values

Properties	Topological Indices				
	$ReZG_1(G)$	$ReZG_2(G)$	$ReZG_3(G)$	$RR(G)$	$AZI(G)$
MW	0.9949	0.9842	0.9689	0.6268	0.9214
BP	0.9421	0.9359	0.8766	0.6897	0.7813
FP	0.9111	0.9057	0.8836	0.6002	0.8045
EV	0.8942	0.8730	0.8531	0.5332	0.7729
MR	0.9772	0.9690	0.9603	0.6025	0.9343
P	0.9773	0.9691	0.9604	0.6025	0.9343
MV	0.9680	0.9524	0.9583	0.5585	0.9458

The respective linear regression models are as given below:

Linear regression models for $ReZG_1(G)$

MW=-25.9227+($ReZG_1(G)$)15.8000

BP=95.886+($ReZG_1(G)$)17.611

FP=45.604+($ReZG_1(G)$)9.913

EV=-29.9303+($ReZG_1(G)$)2.3772

MR=-3.0155+($ReZG_1(G)$)3.9520

P=-1.2243+($ReZG_1(G)$)1.5676

MV=1.3658+($ReZG_1(G)$)10.8000

Linear regression models for $ReZG_2(G)$

MW=12.345+($ReZG_2(G)$)11.651

BP=136.871+($ReZG_2(G)$)13.040

FP=68.522+($ReZG_2(G)$)7.345

EV=36.4793+($ReZG_2(G)$)1.7298

MR=6.3494+($ReZG_2(G)$)2.9209

P=2.4895+($ReZG_2(G)$)1.1586

MV=28.8982+($ReZG_2(G)$)7.9196

Linear regression models for $ReZG_3(G)$

MW=106.9035+($ReZG_3(G)$)0.3020

BP=257.2179+($ReZG_3(G)$)0.3216

FP=129.6528+($ReZG_3(G)$)0.1887

EV=52.0829+($ReZG_3(G)$)0.0437

MR=29.6119+($ReZG_3(G)$)0.0762

P=11.7163+($ReZG_3(G)$)0.0302

MV=89.1597+($ReZG_3(G)$)0.2099

Linear regression models for RR(G)

MW=140.520+(RR(G))4.125

BP=239.365+(RR(G))5.342

FP=143.377+(RR(G))2.706

EV=58.3858+(RR(G))0.5836

MR=39.8646+(RR(G))1.0096

P=15.7840+(RR(G))0.4005

MV=128.562+(RR(G))2.582

Linear regression models for AZIG)

MW=151.3584+(AZI(G))0.9076

BP=319.3783+(AZI(G))0.9059

FP=163.3253+(AZI(G))0.5430

EV=61.2019+(AZI(G))0.1232

MR=39.5313+(AZI(G))0.2344

P=15.65188+(AZI(G))0.09296

MV=114.20605+(AZI(G))0.65448

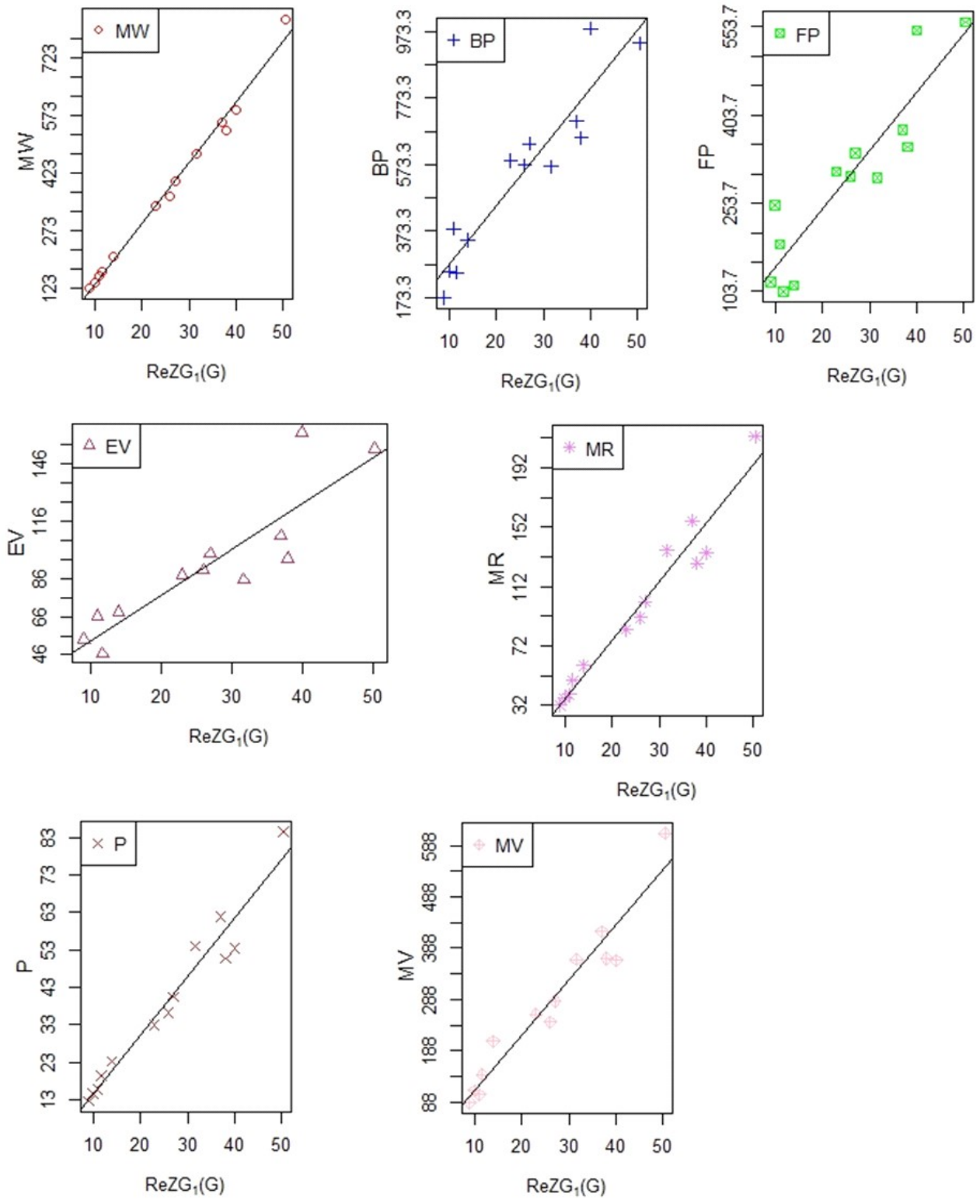

Fig. 1: Scatter plot for physical properties of antituberculosis drugs against $ReZG_1(G)$.

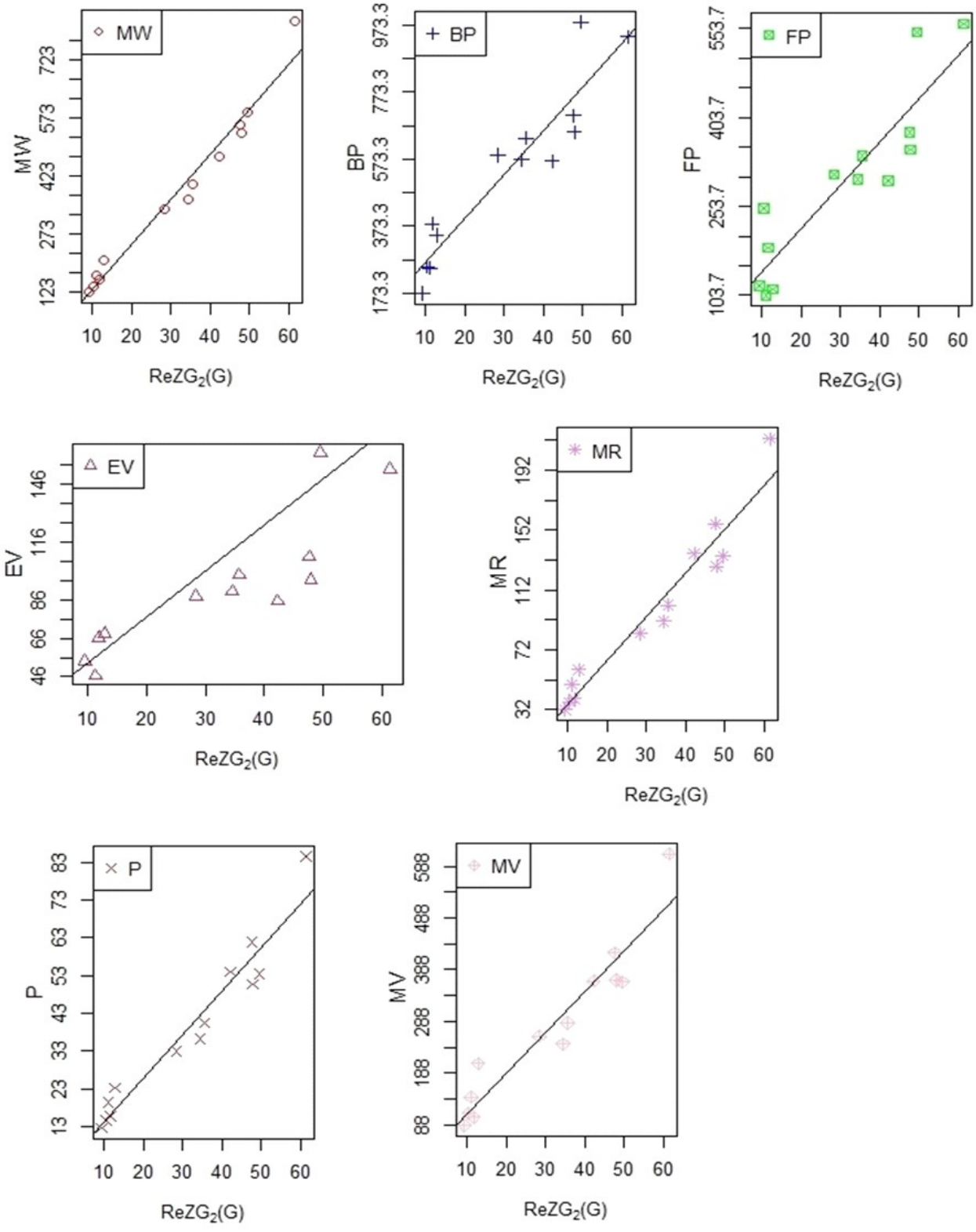

Fig. 2: Scatter plot for physical properties of antituberculosis drugs against $ReZG_2(G)$

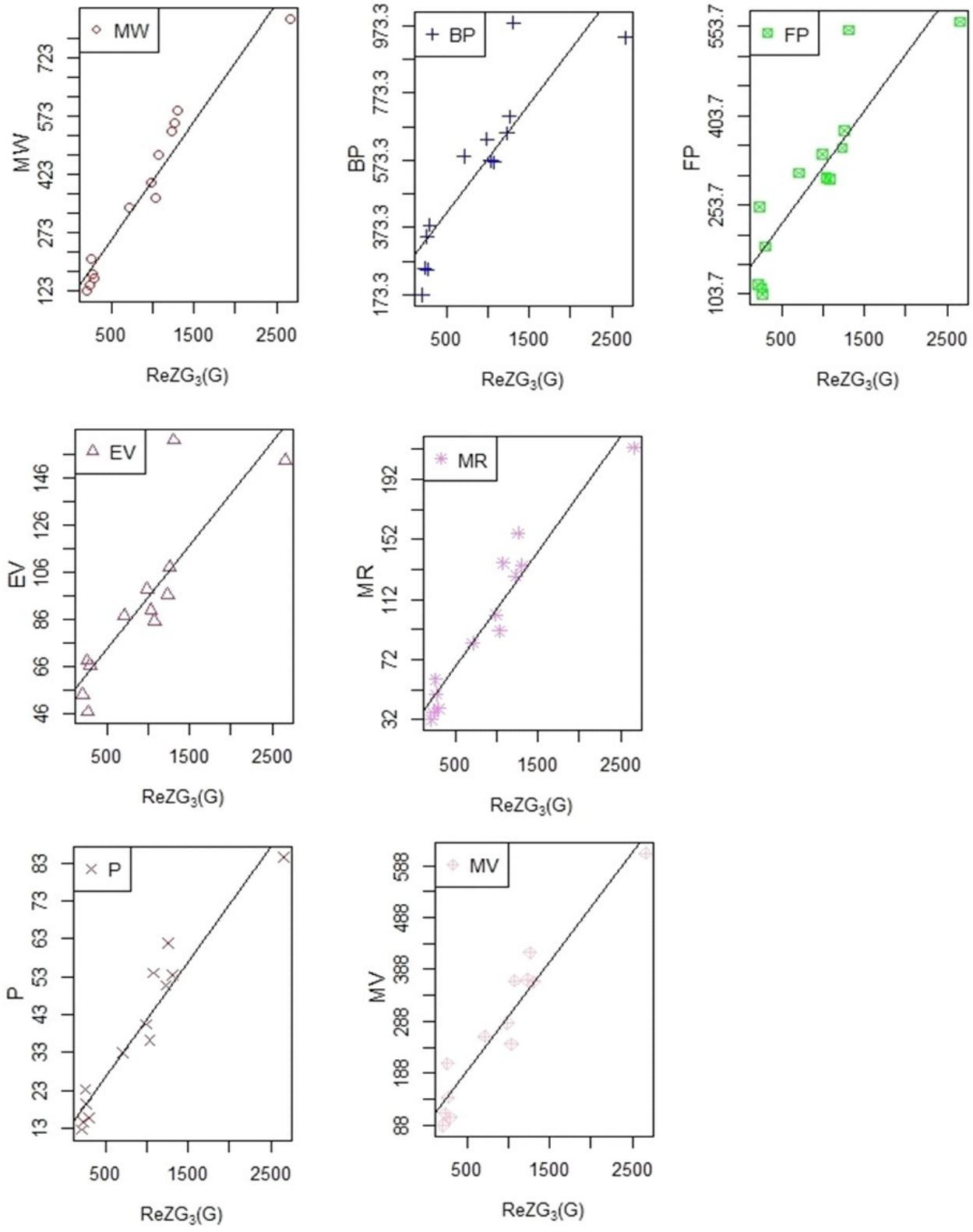

Fig. 3: Scatter plot for physical properties of antituberculosis drugs against $ReZG_3(G)$

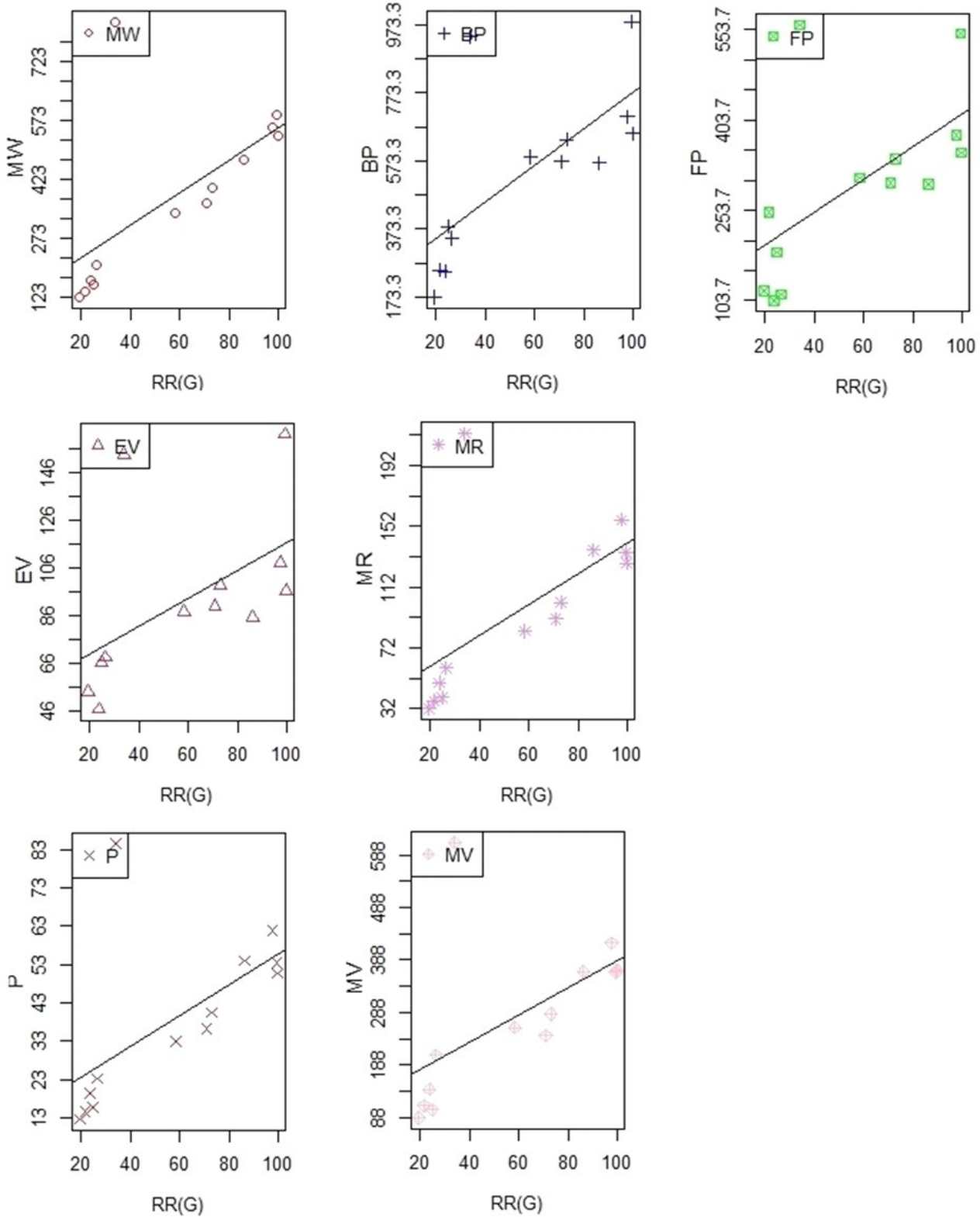

Fig.4: Scatter plot for physical properties of antituberculosis drugs against *RR*(*G*)

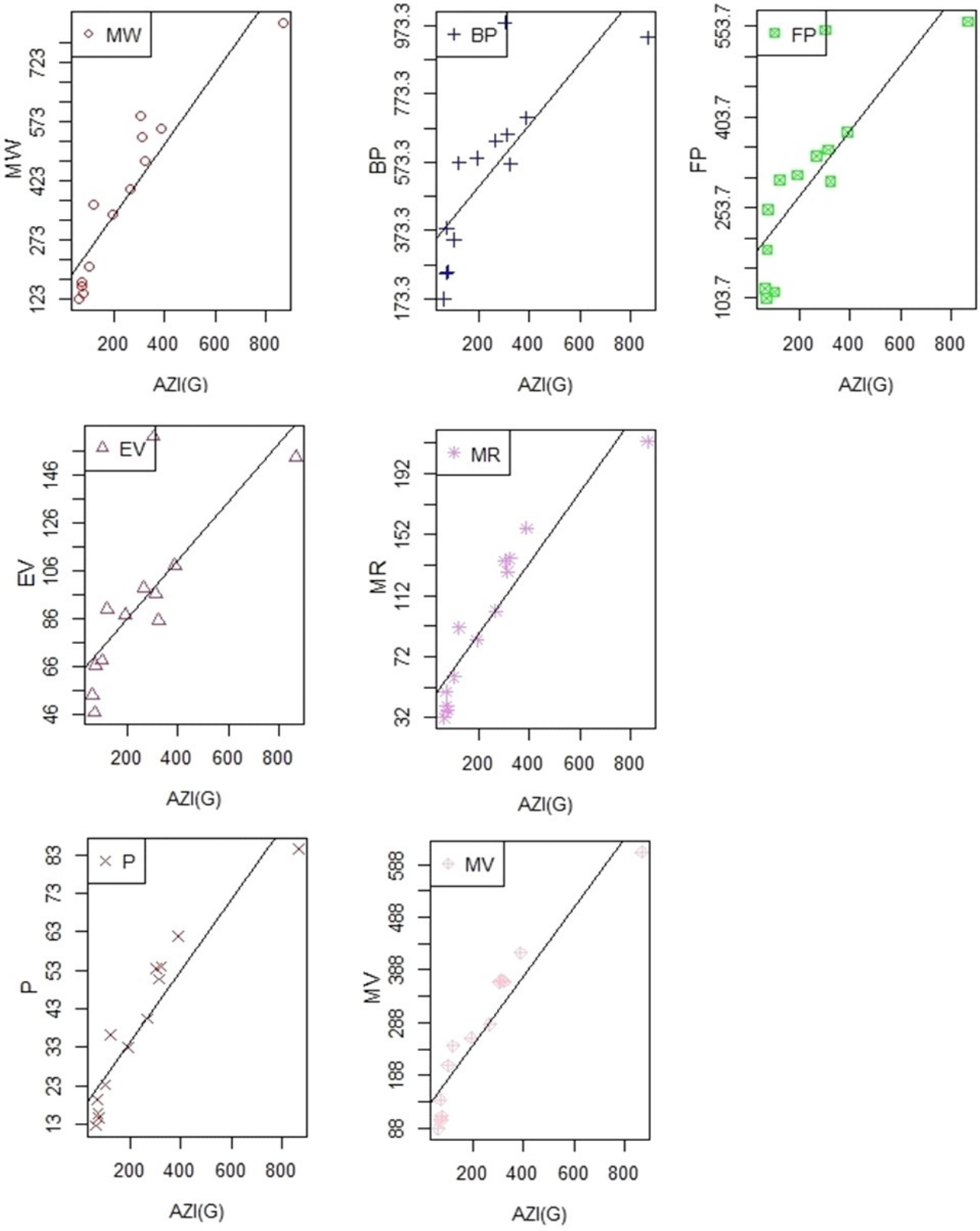

Fig. 5: Scatter plot for physical properties of antituberculosis drugs against *AZI*(*G*)

5.1 QSPR analysis

Examination of the Table 8 shows that the r values of the physical properties of antibiotics used for curing tuberculosis against the considered topological indices range from 0.5332 to 0.9949. Highest r value is observed for $ReZG_1(G)$ against MW with r=0.9949 and lowest is for RR(G) against EV with r=0.5332. Overall, observation of the r values makes clear that $ReZG_1(G)$ shows highest predicting capacity amongst the group of topological indices used for analysis. The second good predictor amongst the considered topological indices is $ReZG_2(G)$. The lowest predicting capacity is that of RR(G) for these properties. Inspecting each physical property in particular, shows that MW and BP are best predicted by both topological indices $ReZG_1(G)$ and $ReZG_2(G)$. $ReZG_3(G)$ and AZI(G) are concluded to be efficient performers monitoring their respective r values.

In the article [1], the r values computed for various TI's used to predict BP of antituberculosis drug range from 0.877 to 0.921. On comparing these r values from [1] with the r values in Table 8, it is noticed that $ReZG_1(G)$ and $ReZG_2(G)$ show highest predicting capacity for BP with r=0.9421 and r=0.9359 respectively. On further comparison of r values for EV which range from r=0.840 to r=0.879 in [1], it is observed in the present investigation that $ReZG_1(G)$ has the best predicting capacity for EV with highest r value i.e., r=0.8942.

6. CONCLUSION

Topological indices play a vital role in predicting the properties of antibiotics in relation to their chemical structures. From the present investigation it is concluded that, amongst the considered topological indices $ReZG_1(G)$ has the highest predicting capacity for BP of antituberculosis drugs. Amidst the degree based topological indices in the literature $ReZG_1(G)$ stands out to be the best topological index to predict the physical properties BP and EV of antituberculosis drugs. Its performance in case of MW is also significant with r=0.9949. A dip is observed in the performance of RR(G). Thus, QSPR analysis acts as a support system to replace experiments for predicting the properties of medicines used to treat diseases.

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