2017

National Research Agenda

Pathway to Shaping the Future

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National Research Agenda

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Introduction

Pakistan Vision 2025 envisions to make Pakistan among the top 25 economies by 2025. To realize this vision, five enablers and seven pillars have been identified which are based on the imperatives of embracing change, transformation, and to create new opportunities based on innate strength. The key five enablers include (i) shared vision, (ii) political stability & continuity of policies, (iii) peace & security, (iv) rule of law and, (v) social justice. While the seven pillars of the Vision 2025 included; (i) *People First*: Developing human and social capital, (ii) *Growth*: Sustained, indigenous, and inclusive growth, (iii) *Governance*: Democratic governance: institutional reform and modernization of the public sector, (iv) *Security*: Water, Energy and Food security, (v) *Entrepreneurship*: Private sector and entrepreneur-led growth, (vi) *Knowledge Economy*: Developing a competitive knowledge economy through value addition, and (vii) *Connectivity*: Modernizing transport infrastructure and regional connectivity. Under the seven pillars, 25 goals have been set which would be accomplished by the year 2025.

The Vision 2025 assumes that the country's untapped potential provides room for optimism that Pakistan could emerge as great nation and economic power if resources are generated, managed and used efficiently. It puts emphasis on knowledge, innovation and entrepreneurship as key drivers of growth and future progress. State-of-the-art technologies like biotechnology and nanotechnology are recognized as instrumental in the creation of core competencies that can provide needed skills and enhance productivity to transform Agriculture, Industry and the services sector over the coming years. The Vision also relies upon indigenous resources and self-reliance to steer the economy to a higher growth trajectory and recognize the primacy of the private sector as the key player for accelerating growth. The aim is to establish a sound socio-politico-economic structure, which fosters and preserves good society, good politics and good economy with responsibility towards the future generations.

Innovation, through focused research and development (R&D), is one of the major thrust areas of the Vision 2025. For this, the Vision envisages establishing the missing link between our knowledge and production platforms through government, private sector and academia/ research partnerships. Science & Technology and R&D can play an important role to realize almost all the goals and targets of the Vision 2025; however, some of the goals, as given below, require direct interventions of science and technology:

- *Higher Education*: Increase in higher education coverage from 7% to 12%.
- *Sanitation*: Increase in proportion of population with access to improved sanitation from 48% to 90%.
- *Efficient and Effective Delivery of Services to Citizens*: Modern performance driven public sector through adoption of technology for efficient and effective delivery of services to citizens.
- *Increased Exports*: Increase in annual exports from US$ 25 billion to US$ 150 billion.
- *Energy*: Double power generation to 45,000 MW and provide uninterrupted, affordable and clean 'energy for all' – electricity access from 67% to 100%.
- *Water*: Increase storage capacity and improve efficiency of usage in agriculture by 20%.
- *Food Security*: Reduce food insecure population from 60% to 30 %.

- *Knowledge Economy*: Improve Pakistan's score on the knowledge Economy index from 2.2 to 4.0.

Technology Foresight is a systematic approach which focuses on the future of science and technology- both as a driver of change and as a response to the needs of society. It involves methodical attempts to look into the longer-term future of science and technology, and their potential impact on society, with a view to identifying the emerging change factors, and the source areas of scientific research and technological development likely to influence change and ensure sustainable development, and thus yielding the greatest economic, environmental and social benefits. It can be described as the use of collective thinking and wisdom to identify priorities and address key future challenges of society and economy. For this it relies upon consulting a wide range of experts, with the expectation that through our collective experience, imaginative abilities and interactive knowledge of technological development pathways, we can begin to construct a coherent view of some of the major developments that can be anticipated within a time period of 10-25 years. Hence, Foresight can be called as the national capacity to think ahead.

Pakistan Council for Science and Technology (PCST), with the aim to provide valuable inputs to policy, planning and strategy undertook technology foresight exercise in various priority areas of national importance such as Agriculture, Biotechnology, Education, Electronics, Energy, Environment, Health & Pharmaceuticals, Information & Communication Technologies (ICTs), Industry, Marine Resources, Nanotechnology and Water. Reports in each of the Priority Area were prepared by the Expert Panels comprising experts from Universities, R&D organizations and the Private sector.

The National Research Agenda has been prepared with the aim to align the national R&D and innovation activities with the Vision 2025 and to provide a direction to the national R&D efforts so that they adequately support achievement of the goals set in the Vision. Indirectly, the document of the National Research Agenda is based on the input of a large number of scientists as it is grounded on the Technology Foresight Reports; which involved about 200 experts in different areas, and the documents of National STI Policy 2012 & National STI Strategy 2014-18; which were prepared by different teams of experts and were circulated to a large number of stakeholders for their views and input, and a team of professionals from PCST.

In the Research Agenda, **fifteen Priority Areas** have been identified which are presumed to be important for national growth and development over the next decade or so. There is a strong connectedness among many Areas and developments in one Area may affect the other Areas as well. For example, developments in the Water sector will impact the Areas of Agriculture, Environment, Industry etc., while developments in the Energy and ICTs sectors will be reflected in almost all other Areas. Priority Areas have been arranged in the order of priority based on the opinion of the members of Executive Committee of the National Commission for Science and Technology (ECNCST). The membership of ECNCST, *inter alia*, includes Minister for S&T and Deputy Chairman, Planning Commission / Minister for PD&R. For each Priority Area, a precise **Problem Statement,** brief **Present State of Development**, **Relevance with the Vision 2025** and its **Potential Socio-economic Impact** has been given. Further, **Focus Areas of Research** under each Priority Area have been identified for more focused efforts within the Priority Area, while **Recommendations** have been made for the overall development of the Area.

It is hoped that document of the National Research Agenda will provide basis of initiation of well-directed and sustained R&D efforts to successfully achieve the Pakistan Vision 2025. However, to make this a reality a strong **political will** of the government; supported by long-term financial commitments, and a true sense of **nationalism** among all stakeholders; evident through solid actions, will be required.

National Research Agenda: Priority Areas

1. Agriculture& Food Security

Problem Statement

The major problems in Agriculture in Pakistan are low per acre yield, increasing water scarcity, degradation of land resources (water logging and salinity), inefficient use of agricultural inputs (specially unbalanced application of fertilizers and inefficient water application), ineffective transfer of technology to the farmers, post-harvest losses and poor marketing infrastructure. Both biotic and abiotic stresses and climatic change are important physical factors increasingly threatening the crops. Heat is a potent threat, with unusually hot crop cycles being experienced more frequently which may cause significant healed losses in wheat, cotton and rice oilseeds and pulses. Crops in arid areas can also be damaged due to prolonged dry spells. It is feared that the climate change associated with global warming will further threaten the crops in future. Pakistan will need to increase its production of major agricultural products (food, feed, fiber, sugar, edible oil, meat, milk, poultry and fish) to feed its growing population and also generate some surplus for export. Lack of value addition in agricultural products is also a big issue in Pakistan e.g. despite being one of the largest milk producing countries in the world, huge foreign exchange is spent on the import of dry milk. Advances in the Agriculture sector are also required in the contexts of the concepts of ‘functional foods’ and ‘one health’.

Present State of Development

Pakistan has diverse agro-climatic conditions, good natural resource base (land and water) and large network of irrigation system suitable for diversified and intensive agriculture production system. Agriculture sector, which comprises 45% crops and 55% livestock, provides livelihood

for 60% of the country's population living in rural areas. It also contributes 21% to GDP, 60% to exports and 45% to employment of the labor force.

In the last few decades, Pakistan has witnessed an unprecedented technological and economic transformation. It was able to achieve food self-sufficiency, triple its agricultural exports, reduced poverty, increase income levels, and improve quality of life of people up to some extent. The transformation started in the late 1960s with the advent of green revolution. The key elements in improving food production since green revolution were the combination of technology package; high yielding varieties, input intensiveness (irrigation and fertilizer); improved policy measures; incentive in the form of input subsidies and investment in agriculture infrastructure (irrigation, research and extension). Consequently, by the end of 20th century, almost all of the irrigated area was cultivated under high yielding varieties, irrespective of farm size, which resulted in sustained increase in the yield of various crops.

In spite of an impressive increase in agriculture production, it did not improve the living standards of the rural population to the desired level. Pakistan's average national crop productivity (yields) is almost at par with the world's averages with major contribution from progressive farmers. However, a major part of the arable land is cultivated by small farmers who hold less than 12.5 acres of land; small farmers are 86% of the total number of farmers. The small farms are continuously increasing because of land division due to inheritance affecting agricultural productivity, as small farmers are generally resource poor.
Pakistan is blessed with tremendous livestock wealth comprising about 34.28 million cattle, 29.41 million buffaloes, 27.76 million sheep and 59.86 million goats. They provide milk and meat to masses and make a substantial contribution to export. Apart from this, livestock play an important role in the subsistence farming of the country as they are used as cash at the time of emergency. However, there is sufficient room for increasing meat production, thus making access to masses.

Relevance with the Pakistan Vision 2025

The Pakistan Vision 2025 seeks a Pakistan where all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. It envisages food security in the context of the entire supply-chain- from production, processing, storage and distribution to consumption. In this regard, it has set the target to reduce food insecure population from 60% to 30%.

Focus Areas of Research

- Genetic modification for higher yields and pest resistance in major crops as well as for improvement of livestock traits (disease / heat resistance, high meat / milk yield).
- Value addition in agricultural products (especially fruits, milk, meat etc.) through novel and innovative food processing and preservation techniques.
- Efficient cropping & irrigation practices
- Better storage and transportation practices
- Development of good quality and disease-free seeds, and Food safety
- Use of remote sensing technology for pest surveillance and monitoring of the irrigation system

Recommendations

- Climate smart agriculture to maintain soil health and resilience for sustainable future food security.
- Data base for livestock and crops, at breed and variety level, on actual basis and readily available for evaluation and decision making.
- Reductions in the wastage (~40% of total) of agriculture produce through infrastructure improvement and installation of facilities for high throughput post-harvest treatment plants at strategic places close to production areas.
- Availability of seeds of recommended varieties be ensured.
- Steps be taken to ensure effective technology transfer from R&D institutions and universities to the farmers'.
- Diversification into high value agriculture and value added products.
- Improving the nutritional quality of staple food to provide essential nutrients such as iron, vitamins, amino acids and proteins.
- Promotion of kitchen gardening and tunnel farming etc.
- Adoption of best production and management practices in livestock, poultry and fish farming.
- A number of scholarships for undergraduate degree training are recommended in Thailand, a country who is excellent in food security.
- Rural development programmes, including infrastructure and education as well as connectivity measures, are also essential to de-urbanization.
- Develop irrigation system to conserve water without compromising yield such as drip and sprinkle irrigation systems.
- Utilization of marginal lands for fodder and wood production
- Introduction of Community based agriculture system backed by export facilitation at community level.
- Strict variety approval and seed production regulations at provincial level by mandatory inclusion of DNA based characterization and purity testing.
- Strengthen existing institutions and/or establish new one (agricultural Advisory institution) which can predict the viability and quantity of any crop required in coming season to protect against deficiency or over production of Agriculture products.

Potential Socio-Economic Impact

Agriculture has been the backbone of Pakistan's economy and has over the years played a pivotal role in Pakistan's economic growth and development. Due to its significant contributions in the GDP, labour employment and providing livelihoods to the rural populations, even a slight improvement in the agriculture sector would mean addition of billions rupees to national economy and up-gradation of living standard of a large population. In nutshell, progress in agriculture sector would impact employment generation, poverty reduction, generation of economic activities, self-sufficiency in food, revenue generation, support to industrial sector and growth and economic wellbeing of rural population.

2. Water

Problem Statement

Pakistan is fast becoming from ‘water-rich’ to ‘water-scarce’ country. In Pakistan, agriculture is the largest sub-sector of water use as it consumes around 93% of total water resources available (surface & groundwater). Due to shortage of water, the agriculture sector is an increasing pressure to balance improvements in productivity with stress on natural resources. The sewage, industrial and agricultural effluents are affecting the quality of groundwater as well as freshwater bodies. Drinking water resources are also shrinking and its quality is a big challenge all over the country. Provision of safe water supply to the growing population of the expanding cities and rural areas in a sustainable manner has become one of the most challenging issues. Due to increase in population and country’s economic growth the demand of domestic and industrial water in future will further grow. The realization for minimum e-flows (environmental flows) in the river system would also be required additional water.

Present State of Development

In Pakistan, as opposed to over 50 % of urban population having access to pipe water supply, only about 26 % rural population have access to pipe water supply at their premises. Adequate water treatment is being provided in few cities and the quality of water does not fully meet the drinking water quality standards laid down by PSQCA and WHO guidelines, in general. Due to the poor quality of tap water in the country has witnessed a mushroom growth in the bottled water industry over the past few years with an annual growth rates nearing 40%. While coverage of sanitation services is hardly 42%. Effluents from agriculture, industry and sewage are being disposed into freshwater bodies, affecting flora and fauna of the IBIS (Indus basin irrigation system) and delta. It has also directly influenced the quality of ground water.

Irrigated agriculture is the major user of both, surface and groundwater resources of Pakistan. The average annual river diversions for irrigation in the Indus Basin are of the order of 104.7 MAF, to irrigate over 14.6 million ha of the command area. An estimated 50 MAF of groundwater is pumped annually in Pakistan. According to a study, more than 90% of the extracted groundwater is used for irrigation purposes. Groundwater reservoirs are recharged from the rivers as well as the seepage losses from the canals, watercourses, farm channels and the fields.

WAPDA, PARC and IWMI have conducted research for enhancing productivity, efficient use of water, and salinity control and management largely during 80s and 90s, when funding was available from donors. But their work was largely focused either at field level or at the level of distributary canal covering narrowly focused specialized research. A comprehensive approach for integrated agriculture production and resource management for sustainable livelihood and ecosystem health was not adopted.

Relevance with the Pakistan Vision 2025

Water security is one of main goals of the Vision 2025 as it aims to increase water storage capacity to 90 days, improve efficiency of usage in agriculture by 20% and, ensure access to safe drinking water for all Pakistanis. Developments in the water sector are also fundamental to achieving goal of 'reducing food insecure population from 60% to 30%'.

Focus Areas of Research

- Application of GIS and hydrological modeling for water resources planning and management
- Recycling of waste water
- Rainwater harvesting
- Techniques for recharging depleted aquifers
- Water conservation technologies
- Monitoring of surface and ground water quality
- Technical assessment survey of water supply schemes
- Development of innovative low cost monitoring kits
- Development of treatment technology for water and waste water
- Membrane Technology

Recommendations

- Enhancing national water storage capacity and safe drinking water coverage on war-footing basis.
- Strengthening relevant R&D organizations thus to focus on conducting demand-driven R&D so that technologies and products can be developed which are readily adopted by the agricultural, industrial and domestic clients.
- The industry needs to be motivated for being active partners in modernizing and managing their industrial processes for water efficiency.

- The local municipalities, in active partnership with the S&T institutions and the private sector, devise mechanisms how technological processes and cost-effective technologies can be introduced to improve the performance of water supply and sanitation systems.
- NGOs, R&D institutions and the private sector should be linked together for creating awareness about the technologies, processes and best practices at a large scale.
- The agricultural policies should focus on increasing productivity as well as water efficiency by reducing on-farm water losses, adopting high efficiency irrigation techniques and best practices for the design of cropping patterns.
- Recycling of household grey water for its usage for lawn irrigation / gardening.

Potential Socio-Economic Impact

Water, perhaps, is one of the most important natural resources on earth, without which life is impossible. The potential impact of improvements in water sector will be evident through enhanced agricultural productivity & food security, improved human health and decreased costs of health care as well as improved environment and increased productivity in the industrial sector.

3. Energy & Fuel Cell Technology

Problem Statement

Pakistan has been facing an unprecedented energy crisis for the past few years as the demand and supply gap widens. Energy is the key determinant of economic development and social prosperity of any society. It also provides an impetus for keeping sustainability in economic growth, hence, it is the key area which need to be addressed if the Vision 2025 has to be realized.

Present State of Development

Conventional Energy Resources

Pakistan is amongst those countries which are blessed with huge reserves of various sources of energy including fossil fuels such as oil, gas and coal. The details about the potential of conventional energy resources are given as below:

Hydroelectricity	46,000 MW identified potential
Coal	185 billion tons
Crude Oil	326 million barrels proved reserves
Natural Gas	26 trillion cubic feet proved reserves
Uranium	236 tons used for nuclear power generation since 1980

Despite possessing these huge energy resource, Pakistan has been unable to exploit these to derive economic growth and development. Pakistan produces just 0.1% of its total electricity from coal. This is in sharp contrast to other countries such as USA (52%), UK (58%), China (78%), Australia (77%), India (77%) and South Africa (88%), where coal is still one of the major source of power generation. Pakistan's current energy demand far exceeds its indigenous

supplies of fossil fuels fostering dependency on the imported oil that put substantial burdens on the economy. Energy crisis, which has worsened since 2007, is adversely affecting the economic growth and, in case of its persistence, the accomplishment of the Vision 2025 would be nothing more than a dream. Our immediate national agenda should be to acquire energy from whatever sources to meet current requirements but at the long term basis we need to focus on alternate energy.

Alternate Energy Resources

Pakistan can supplement its fossil fuel supplies with renewable energy alternatives. This would also reduce the environmental and health related issues which arise from the use of fossil fuels. At present, the contribution of alternative energy in the overall energy mix of Pakistan is negligible. Therefore, rapid increase in the share of renewable energy in the overall energy mix is a must to meet the present and projected energy demands of the country as well as addressing environmental issues related with the use of fossil fuels. According to the estimates, Pakistan has huge potential of renewable energy resources as detailed below:

Wind Energy	0.35 million MW
Solar Energy	2.90 million MW
Bio Gas	2.00million MW
Small Hydel	2.00million MW

Relevance with the Pakistan Vision 2025

Addressing the issue of energy is absolutely crucial for achieving the Vision 2025, without which the Vision cannot be materialized without ensuring adequate energy supplies. The role of research and technology will be important for achieving many targets of the Vision such as doubling power generation to over 45,000 MW, increasing electricity access from 67% to over 90% of the population, reducing average cost per unit by over 25%, reducing distribution losses (10%), increasing percentage of indigenous sources of power generation to over 50% and developing energy efficient appliances/products.

Focus Areas of Research

- Development and adoption of indigenous technologies.
- Development and commercialization of cost-effective and high quality products such as PV panels / devices, water heaters, solar thermal power generation etc.
- Ultra low head micro-hydel plants
- Urban waste gasification and use of biomass to produce power
- Renewable energy technologies such as utilization of wind energy with emphasis on wind farming covering the turbine technology, generators and blade development
- Energy-efficient appliances and technologies
- Utilization of microbes and plants for the production of Biofuels and Biogas
- Alternative transportation systems which are low-cost, based on alternative energies, mechanically efficient and that can be built inside the country.

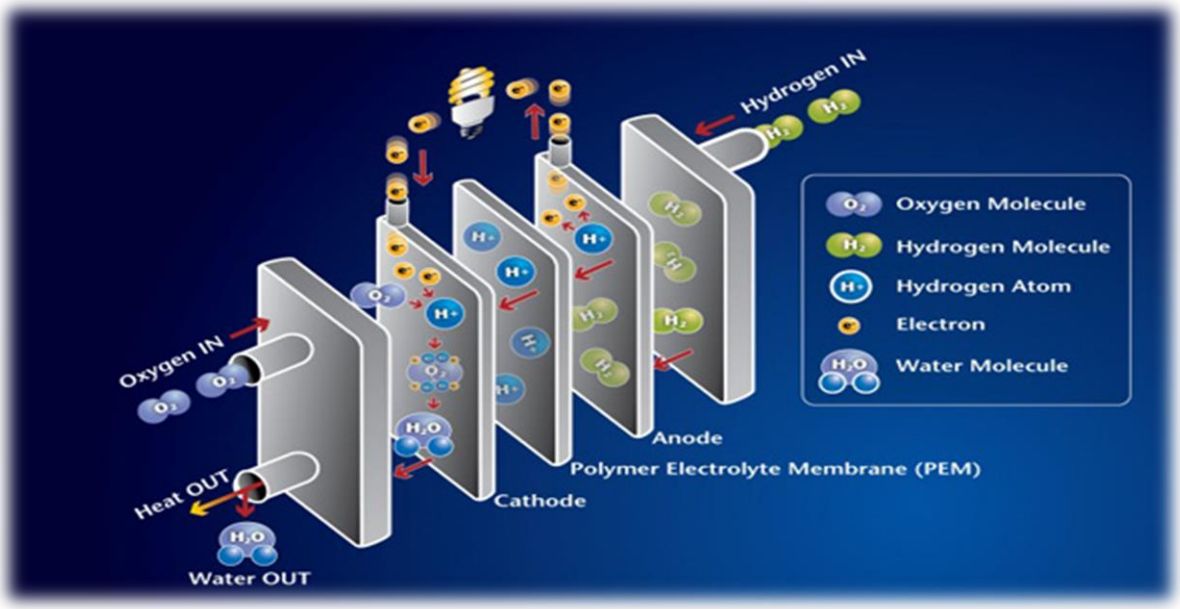
Recommendations

- Industry be encouraged to switch over gradually to energy efficient and renewable energy technologies.
- Attention be paid to Municipal solid waste utilization as RDF (Refuse Derived Fuel) in cement industry and other energy purposes.
- Awareness raising campaign amongst masses regarding usage of renewable energy and energy efficient technologies be ensured.
- Education and training of architects on energy efficient design of buildings and capacity building of Building Control Authorities for evaluation of buildings, in the context of energy efficiency, for granting NOCs.
- Standardization of various industrial processes for energy efficiency be done.
- Involve big construction and housing schemes in establishing and promoting energy efficient houses / buildings. The concept of zero-energy buildings be promoted, especially in government departments housing schemes.
- Use of solar thermal geysers be encouraged.
- Support and incentives for R&D in energy efficient and renewable energy technologies and, support for commercialization of these technologies.
- Educating the public and strictly implementing the energy saving measures.

Potential Socio-Economic Impact

Undoubtedly, energy sector holds the key to economic progress and sustainability of any country and Pakistan is no exception. Improvements in the energy supply and controlling demand will virtually lead to improvements in all the sectors of economy. It will particularly affect industry, agriculture and transport sectors as well as job creation and economic development.

Fuel Cell Technology



Problem Statement

Although, the Fuel Cell Technology is a part of the alternative energy resources, but due to the importance of this technology, for meeting future energy requirements, it is being treated separately. The world is moving towards hydrogen economy, made possible by state-of-the art hydrogen fuel cell technology; which convert hydrogen and oxygen from air to electricity, water & heat. Fuel Cell Technologies are widely regarded as the key means for converting hydrogen to energy and, as such, have a clear enabling role in realizing aspirations for a hydrogen economy. Development of hydrogen fuel cell technology for commercialization and application as energy sources is need of the hour. However, the country is lacking sufficient qualified professionals in this area.

Present State of Development

Many countries of the world including developed and developing are using renewable energy technologies to meet their energy requirements. Unfortunately, the picture is dismal in Pakistan; total renewable contribution in energy mix scenario in Pakistan is less than 1%.

In Pakistan, Fuel Cell Technologies have a vast potential to contribute significantly in providing clean and sustainable energy source for automobiles and power generation. In the shape of Thar coal deposits, we have an enormous coal resource. Similarly, being an Agrarian economy, there is huge potential in Pakistan for conversion of biomass to bio-methane and bio-ethanol. Additionally, there exists an extensive infrastructure for storage and transport of methane. Pakistan can use these strengths to capitalize on the fuel cell potential on two fronts. Firstly, this technology can be used to replace fossil fuel burning power plants and secondly, smaller units could be used to replace the combustion engines used in our cars.

For shifting towards the hydrogen economy in Pakistan, in first stage, hydrogen can be mixed along with natural gas to fuel the internal combustion engines. Development of initial prototypes and subsequent real systems for power generation, thereby, overcoming the power shortage in the country by using zero emission, environment friendly technologies. Development of the hydrogen storage and distribution networks may be taken in the mid-term planning.

Relevance with the Pakistan Vision 2025

The Vision 2025 recognizes the importance of alternative fuels, in addition to fossil fuels. Fuel Cell Technology has the promise to significantly supplement or even replace the fossil fuels in future, therefore, it is important to build capacity in this technology. This is also relevant to achieving the goal of 'becoming one of the largest 25 economies in the world'; as this would mean significant increase in the demand of energy and Fuel Cell Technology can contribute in meeting that demand.

Focus Areas of Research

- Alkaline Fuel Cells Technologies
- Phosphoric Acid Fuel Cells
- Proton Exchange Membrane Fuel Cells/ Polymer Electrolyte Fuel Cells
- Solid Oxide Fuel Cells
- Molten Carbonate Fuel Cells
- Hydrogen Storage Technologies/ Hydrogen Network
- Direct Methanol Fuel Cells
- Fuel cells for transportation (Motorcycle/Rickshaw and Cars)
- High temperature fuel cells for stationary applications (to cover the requirement of single home/office)

Recommendations

- Establishment of National Centre for Fuel Cell Technologies" and "Hydrogen Production".
- Development of infrastructure and laboratories with strengthen the professionals.
- Hybrid system for poly-generation and development of fuel flexible
- Harmonizing the efforts made in the energy sector by different Ministries, departments and research centres by creating an 'Energy Council' with heads of relevant organizations for better coordination as well as advice on priority areas for R&D.
- Research and development in the catalysts like platinum, cobalt oxide, ruthenium Oxide, iridium Oxide, Nafion Membrane and polymer added light weight economical materials, etc.

Potential Socio-Economic Impact

Acquiring capabilities in the development of Fuel Cell Technologies would result in reduced oil consumption, highly efficient energy conversion, reduction of average cost of per unit production, enhanced fuel flexibility (use of diverse, domestic fuels, including clean and renewable fuels) and reduced air pollution. It would also contribute to achieving the dream of making Pakistan one of the largest 25 economies in the world by 2025 as well as having positive social impact.

4. Health & Pharmaceuticals

Problem Statement

Pakistan is ranked 6th out of 22 high disease-burden countries in the world. This is because the health care system of Pakistan features several problems due to poor performance of immunization and mother & child health care programs, communicable and non-communicable diseases and resource scarcity. Due to rapid growth of non-communicable diseases, for which there is no satisfactory care with pharmaceuticals, the significance of preventive measures including pure and appropriate diet has been realized. Consequently, a need to adopt one health concept which is now a worldwide strategy for expanding interdisciplinary collaboration and communication in all aspect of health is universally realized. Even though, we have a network of Pharmaceutical companies but the system is heavily dependent on import of raw material.

Present State of Development

Pakistan has registered a significant decline in its child and maternal mortality rates since 1990. Health and nutrition expenditure has significantly arisen during the past 15 years or so. Government is running different programs to combat health issues such as programme for Family Planning and Primary Health Care, Expanded Program for Immunization, Malaria Control Program, TB Control Program, HIV/AIDS Control Program, Maternal & Child Health Program and Prime Minister's Program for Prevention and Control of Hepatitis in Pakistan. At the same time emergence of new diseases, like Dengue fever, is on the rise with alarmingly increasing incidence of non-communicable diseases such as diabetes, high cholesterol & blood pressure, other heart diseases and cancer. However, the progress indifferent health indicators is slower than many other countries and we have not achieved the targets set under the Millennium Development Goals. Pakistan's current spending of around 2% of its GDP on

healthcare system is much below than what is being spent by the developed and even many developing countries. Moreover, the basic manufacturing of Pharmaceuticals has remained ignored completely.

Relevance with the Pakistan Vision 2025

'Pillar I: Putting people first - developing human and social capital' of the Vision 2025, emphasizes on improving health care system and sets targets to reduce infant mortality rate from 74 to less than 40 (per 1000 births) and reduce maternal mortality rate from 276 to less than 140 (per 1000 births). Similarly, the target of reducing the incidence/prevalence of Hepatitis, Diarrhea, Diabetes and Heart Diseases by 50% is also part of the Vision.

Focus Area of Research

- Indigenous development and manufacturing of vaccines against various diseases (human/ livestock/ poultry)
- Manufacturing of basic pharmaceutical ingredients
- Pharmacovigilance
- Value-addition in indigenous herbal wealth
- Clinical Pharmacology
- Development of essential diagnostic kits
- Nanomedicines
- Biomedical and Diagnostic system
- Telemedicine
- Nutrition and functional food

Recommendations

- Promotion of one health approach to monitor and control public health issues.
- Development of preventive care strategies.
- Establishment of raw material production plants in Pakistan.
- Promotion of E-health and tele-medicine.
- Establishment of health R&D fund in the health and pharmaceutical sector to promote the R&D activities including basic medical instrumentation
- Genetic testing for pre-marital, fetus, newborn screenings
- Promotion of ethical and moral values in healthcare system.
- Banning export of herbal raw material without value addition.
- Programs awareness, knowledge and practices of parents and families as well as health education in schools regarding preventive measures including vaccination and healthy life style & dietary habits.
- Capacity building in all the four major aspects of healthcare i.e., medical, nursing, pharmacist and allied health services as well as in Biomedical Engineering (repair & maintain equipment).

Potential Socio-Economic Impact

Focusing on R&D in health and pharmaceuticals would bring enormous socio-economic benefits to the country as good health care system, along with good education system, is fundamental for achieving any economic and social development goals. E-health will play a key role in providing clinical health care, especially to those living in distant rural areas. It will also reduce the burden from the hospitals; thus improving the overall efficiency of health services. Genetic testing would play an important role in the diagnosis of vulnerabilities to inherited diseases at initial stages of life. Successful implementation of immunization programme, along with education on nutrition and life style modification, would result in a healthy young generation. Indigenously manufactured pharmaceutical and herbal medicines can give a boost to the economy through reduction in imports and increase in exports.

5. Climate Change & Environment

Problem Statement

Pakistan is included in the list of environmentally vulnerable countries. The environmental issues and challenges being faced by Pakistan include natural resource degradation, depletion & pollution of fresh water resources, heavy use of pesticides, noise & air pollution, solid waste pollution, soil degradation, desertification, biodiversity loss and improper discharge of industrial waste in addition to consequences of climate change / global warming. Pakistan also faces other severe environmental issues and challenges caused by natural hazards such as, floods, earthquakes, droughts and cyclones. The situation is further complicated and worsened by the prevalence of a sense of apathy in the people, at all levels, regarding the environmental issues.

Present State of Development

The ecosystems in Pakistan have been bestowed with diverse resources which have contributed to the economic development of the country. However, ever increasing population and improper utilization of these resources has led Pakistan to an alarming situation. Pakistan suffer heavy losses due to flooding, erosion of fertile soil, siltation of reservoirs and irrigation system almost every year. Marine environment has been severely polluted by discharge of industrial and domestic sewage. The 'Smog' seriously affects almost entire Punjab in December & January every year. Efforts to rectify the situation have not brought significant improvements due to the lack of institutional capacities, lower emphasis on environment in Government fiscal policies and insufficient allocation of funds for protection and mitigation of environment.

Relevance with the Pakistan Vision 2025

Although, the Vision 2025 does not set any explicit targets for rectifying the environmental degradation and mitigating the adverse effects of climate change, however, it recognizes that the major threat is posed by climate change, associated with increased frequency and intensity of floods and hurricanes, prolonged droughts and growing water stress, shift of disease vectors, and the frightening possibility of the melting of the Himalayan ice-cap. It also acknowledges the decline in biodiversity and key natural resources as well as possibility of energy scarcity in future (necessitating the need of exploring renewable energy resources). Therefore, the issue of environmental sustainability is in-line with the Vision 2025. Further, in the context of sustainable development, balancing economic and social development with the environmental development is absolutely essential.

Focus Areas of Research

- Prediction of future climatic variation
- Green manufacturing
- Forests, Biodiversity and Glacial studies
- Reduction of adverse impact of industrial waste and emissions on environment
- Use of biotechnology for environmental protection
- Alternative sources of energy
- Recycling of solid waste and waste water treatment systems
- Cost effective technologies for the control of particulate matter emissions from stationary sources
- Urban climatology, impacts of climate change on built environment and designs
- Integrated Water Management
- Productive uses of waste materials
- Identifying health hazards of air pollution, such as LEAD and remedification.

Recommendations

- Promotion of environment-oriented awareness, education and R&D
- Development and use of environment friendly technologies.
- Popularization of recycling technologies developed within the country.
- Minimizing use of chemical pesticides and increasing / promoting organic farming.
- Developing photo-degradable material as replacement of plastic bags.
- Introduction of Green Labeling.
- Establishment of seed-banks for preserving biodiversity resources.
- Popularization of the concept of ‘reverse forestation’.
- Legislation for making rain water harvesting essential at household level.
- Encouragement and motivation of Industry for recycling their wastes.

- Promoting the use of ozone friendly substances in-line with the provision of the Montreal Protocol.

Potential Socio-Economic Impact

Addressing the issue of environment would not only result in a great success of resource conservation but would also have positive impact on economy through ensuring savings in the area of health care and other economic costs of the environmental degradation.

6. Biotechnology

Problem Statement

Biotechnology has enormous potential to provide solutions to most of the societal problems relating to food security, health, environment, energy and forensics. It is being argued that biotechnology will shape the future research and its economic impact will surpass the information technology. The impact of modern biotechnology on society is now obvious but real benefits to the society are yet to come as more and more technologies are being developed and their novel applications are being continuously discovered. Therefore, having an organized and efficient biotechnology R&D system is important for Pakistan to meet the demands of sustainable development through food, feed, livestock, environment and health security with increased employment.

Present State of Development

The development of any nation is dependent on technological exploitation of its natural and human resources. Biotechnology provides a promising way to skillfully exploit the natural resources. It also enables to preserve the national resources through their characterization and conservation. Globally, huge investments are being made in the biotechnology research and consequently, biotechnology industry is emerging at a rapid pace.

In Pakistan, the work on biotechnology was initiated with the establishment of Nuclear Institute for Agriculture and Biology (NIAB) in 1972; later on National Institute for Biotechnology and Genetic Engineering (NIBGE) was also established. At present, the number of organizations

(R&D organizations and University Departments) engaged in biotechnology research has increased to more than 30. However, the biotechnology industry, in Pakistan, is still in its elementary stage.

Relevance with the Pakistan Vision 2025

The Vision 2025 has identified Biotechnology as one of the six emerging technologies which are likely to drive the future of development. Improvements in biotechnology will also be important to achieve targets related to food security, human health and environment.

Focus Areas of Research

- Development of indigenous vaccines against diseases such as hepatitis, malaria, cholera, influenza etc.
- Development of procedure for the PCR based diagnosis of different infectious diseases including Dengue virus & *Helicobacter pylori* to enhance diagnostic capability and develop indigenous diagnostic kits
- Development of transgenic plants for enhanced yield, stress tolerance, herbicide resistance, balanced nutrition, better water and nutrient utilization capacity
- Brain–Machine Interfaces for rehabilitation and augmentation in both animals and humans
- Gene therapy for treatment of genetic diseases, and viral therapy for cancers
- DNA fingerprinting and modern DNA recombinant technologies
- Utilization of biodiversity for commercializing the health related natural products and bio-generic drugs
- Bio-protection of material and products; bio-herbicides and weed control
- Whole genome sequencing of indigenous microbes coupled with Bioinformatics applications
- Reverse engineering of biopharmaceuticals and their commercialization keeping social impacts in mind.
- Prenatal and neonatal diagnosis.

Recommendations

- "Revival" of National Commission of Biotechnology (NCB).
- The sector-wise flagship status in different areas of biotechnology must be given to the institutions with clear mandate.
- Support be focused to the target oriented research to fulfill the increasing demand of food, feed, fiber, livestock, environment and health security.
- The scientists be encouraged to develop cost-effective and product oriented patentable and deliverable outputs.
- The private sector be encouraged to invest in biotechnology based businesses and support biotechnology R&D in public/private institutions.
- The national bio-safety agency be strengthened and a national bio-safety policy be developed.

- Promotion of bio-fertilizer to reduce use of chemical fertilizer and thus decrease cost of production of major crops.
- Policy for the import and introduction of GM crop from foreign companies and regulation of seed quality.
- Promotion of entrepreneurship and technology parks for application of biotechnology for industrial applications.

Potential Socio-Economic Impact

The systematic R&D in Biotechnology and resultantly developed industry would significantly contribute in the socio-economic development of the country. It will particularly impact the areas of Agriculture & food security, human health, environment, industry and forensics.
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7. Information & Communication Technologies (ICTs)

Problem Statement

ICTs are important sector of economic activity, achieving high growth rates in developed as well as in developing countries. ICTs offer developing countries, like Pakistan, the opportunity to leapfrog several stages of development by using frontier technologies that are more practical, environmentally sound and less expensive than undergoing the traditional stages and cycles of progress to the Information Society. Pakistan has made a significant progress in the development of ICTs during the past decade or so. However, it still finds itself far behind to a large majority of the countries as it has not sufficiently leveraged the potential of ICTs to boost national competitiveness and well-being of masses. Improved performance in ICT sector is also crucial for the development of knowledge-based economy in Pakistan and increasing efficiency in different walks of life.

Present State of Development

ICT industry in Pakistan is at crossroads. Some progress has been made by liberalizing the sector and its growth has increased substantially in recent years, but the available internet and broadband-based social services are still far from meeting the country's needs. Pakistan has the resources and positioning to become the central hub for telecommunications in the Gulf and Asia-Pacific region. However, focused and sustained efforts are required to make Pakistan a communications hub for the region. Presently, Pakistan's rank in the Networked Readiness Index is 112thout of 143 countries. Therefore, the country needs to develop its infrastructure and internal capacity to improve its overall performance in the ICT sector. R&D and innovation for development of ICTs has to be emphasized if Pakistan aims to catch up with the leaders in the sector.

Relevance with the Pakistan Vision 2025

ICTs are central to achieve some of the goals set under the Vision 2025 such as improve Pakistan's score on the World Bank Institute's Knowledge Economy Index from 2.2 to 4.0 and increase internet penetration to over 50%. This sector can also play a significant role in achieving other targets such as increase annual exports from US$ 25 billion to US$ 150 billion, become one of the largest 25 economies in the world and reduce poverty level by half; in addition to improving efficiency of individuals and governance systems.

Focus Areas of Research

- Development of e-governance applications including electronic national voting
- ICT based solutions to the preservation of national and local languages, including the design of new easily translatable fonts for usage on the internet and smart phones.
- Women empowerment through ICT training to Women Professionals
- Research in the areas of e-Education, e-Health, e-Agriculture, e-Governance etc.
- Development of ICTs for businesses
- R&D in the area of Internet Protocol version
- Artificial intelligence and machine learning
- Internet of Things (IoT) Technology
- Big data and predictive maintenance technology
- Next Generation Networks (NGNs)
- Cyber security and Information security
- Social media research and application

Recommendations

- Appropriate policies may be adopted to ensure that the benefits of the ICTs, in real sense, reach to those who deserve them the most.
- Establishment of public ICT parks.
- The concept of 'e-village' be introduced in Pakistan to extend benefits of ICTs to the door steps of rural population for uplifting their social, educational, health care and economic infrastructure as well as to minimize digital divide in Pakistan.
- Advancements in the ICTs be harnessed to provide e- learning opportunities to both urban and rural populations.
- Cyber Entrepreneurship be encouraged and supported by providing advice, guidance, training and financial assistance, especially to youth and fresh graduates.
- Promote Smart phone Application development as a core competency among computer science graduates
- Establish Venture-Capital Fund using public-private partnership model.

Potential Socio-Economic Impact

Improved ICT sector would help to provide better educational, health and other social services to a vast majority of population which otherwise may not be possible. Opportunities of employment and self-employment would be increased to a significant level which would also help in reducing poverty. Development of ICTs, through R&D and innovation, would increase exports, contribute in enhancing GDP, lead towards building knowledge-based economy and information society as well as raising Pakistan's level to upper middle income country.

8. Mineral Resources

Problem Statement

Generally speaking, the mineral sector in Pakistan to a greater extent remained neglected by all concerned and could not witness progress and prosperity that we normally see on other areas on which the economy of the country is much dependent. Very little, rather insignificant R &D efforts were made to develop this sector on scientific lines in our country and that is the main reason this sector so far failed to contribute to the national economy. There is a wide spread lack of awareness about the potentials of this sector that has resulted in poor performance in the national economy. It has been a general agreement among all concerned about vast potential of the Minerals sector in Pakistan but looking at the technical progress it proves otherwise. Except a couple of projects having national level significance like Saindak Copper-Gold, and recent improvements in dimension stone sector, rest of mining industry is not fully developed and need serious attention.

However, unlike other developing countries with good mineral endowment, it has not yet been able to promote growth and alleviate poverty by exploiting its natural resources to maximum extent possible. The development of its mineral resources has been limited to numerous quarries producing industrial minerals of limestone, rock salt, marble, gypsum and a modest amount of coal for internal power generation. The estimated share of Pakistan in the world gem and jewelry market is 0.05%, but it is estimated that Pakistan could grow substantially its market share if it adopts policies conducive to enhance value added conditions and activities. The gemstone industry in Pakistan is not receiving institutional support to develop value added activities e.g. cutting, polishing and exporting incentives as in neighboring India. The difference between the price of an uncut and cut and polished gemstone varies from 1:30 to 1:100 for cut and polished colored gemstones. Moreover, the Public Mining Institutions lack the technical capacity, managerial skills, and material support for the implementation of the National Minerals Policy in order to improve the development of the mining sector.

Some of the issues /problems related to the development of mineral sector include;

i. Mismanagement
ii. Inadequate technical and skilled workforce
iii. Lack of development funding
iv. Inadequate allocation of funds for mineral exploration and research
v. Lack of technology
vi. Political instability/lawlessness in areas important for mining e.g. Khyber Pakhtunkhwa and Balochistan
vii. Non availability of soft loans for undertaking development activities in the mineral sector
viii. Formal education and training in mineral sector is not in line with needs and requirements of our mineral industry, resulting in technical manpower not appropriately trained to solve the problem of mineral industry.
ix. There are no or weak linkages between the mining companies, entrepreneurs and the researchers.
x. The nature of impediments in making a road map with fixed milestones and time frame is of diversified nature, i.e. also related to legal, political, social and interprovincial misapprehensions.
xi. The use of primitive methods for mining deposits of dimension stones including granite, marble is resulting in great loss and wastage

Present State of Development

Pakistan is rich in mineral resources, offering a great potential for economic development and prosperity. Based on available information, the country's more than 600,000 square kilometers of outcrops area sustain varied geological potential for deposits of several minerals notably coal, copper, zinc, gold, chromite, mineral salt, and bauxite. There are also varieties of precious and semi-precious mineral, including peridot, aquamarine, topaz, ruby, emerald rare-earth minerals bastnaesite and xeniotime, sphene, tourmaline, in addition to various types of quartz.

The Mineral sector is recognized as a high-potential sector in Pakistan in terms of its scope for future growth, value added products, export diversification, job-creation and private sector development in both rural and urban areas of Pakistan. At present, out of 92 known minerals in the country, 58 are being mined on small scale. The major production is of coal, rock salt and other industrial and construction minerals. The current contribution of minerals sector to the GDP is only less than one percent (about 0.5%), compared to 8.5% for Chile, 5.6% for Australia, 3.6% for Canada, and 1.6% for USA. The contribution of the mining sector in Pakistan, however, is likely to increase considerably upon the development and commercial exploitation of Saindak and Reko Diq gold and copper deposits, Duddar zinc and lead, and coal and Gemstone deposits in Thar. Pakistan Mineral Development Corporation is an autonomous corporation under the administrative control of Ministry of Petroleum and Natural Resources, Government of Pakistan.

The known minerals are wide spread in all the provinces including Azad Jammu & Kashmir, Gilgit Baltistan and FATA. Baluchistan is by far the richest province in Pakistan in terms of mineral resources (metallic, non-metallic and dimension stones). Punjab has the second largest reserves of rock salt in the world, and Khyber Pakhtunkhwa (KPK) is the richest 8 province in terms of gem stones. Sindh has the 5th largest coal deposit in the world. The major production of Pakistan is of coal (Punjab, Baluchistan, Sindh and KP), rock salt (Punjab and KP) and a number of industrial / construction minerals /rocks from different parts of Pakistan.

Pakistan is also enriched in the gemstone and precious, semi-precious, mineral specimens, ornamental stones deposits. In the present arena there is constant shift in the global trade of gemstones due to rapid change in the demand for shapes, cuts, colors and type of gemstones. At present the world trade for colored gemstones is dominated by Thailand, Switzerland and India. About 19 varieties of precious and semi- precious gemstones including Emerald, Ruby, Topaz, Aquamarine, Tourmaline, Quartz, Moonstone, Zircon, and Onyx etc. are mined and traded in Pakistan. The availability of raw material, relatively low cost and experienced labor force, and growing international markets, are key advantages giving Pakistan a potential edge in global trade in this sector.

As a result of implementation of National Mineral Policy 1995, a number of international mining companies undertook various activities which produced good results such as discovery of a sizeable copper-gold deposit of Reko Diq, Baluchistan. But due to certain reasons (poor governance and lack of interest), the pace of development of these deposits is quite slow rather disappointing. The national mineral policy was revised in 2013.

Pakistan's mining industry covers the exploration and extraction of minerals and the associated mineral processing industry. Pakistan has more than 5,000 operational mines employing nearly 300,000 workers. The production of minerals is important for the growth of mineral based industries such as energy (coal); agriculture (phosphate, gypsum); construction (limestone, natural stones); and manufacturing (copper, gold, silver), cement (limestone, clay and gypsum), chemical factories (rock salt), Glass and ceramic industry (silica sand and china clay).

Relevance with the Pakistan Vision 2025

The strategy for realizing the vision incorporates a number of elements including specialized training, incentives for extraction and value addition; development of adequate infrastructure facilities near mining sites; learning from best practice in other countries regarding development of the mineral sector and will apply those to the country's own sector.

Focus Areas of Research

Research in the areas of solution mining, materials handling, equipment, human factors, fragmentation, systems integration, and automation and robotics will improve productivity and energy efficiency for exploration of minerals:-

- Identifying minerals, chemical composition and physical properties directly in the field.
- Modeling mineral deposits and their potential economic assets.
- Optimization of exploration, development and exploitation of minerals
- Value-addition of minerals into chemical/product
- Development of chemicals form industrial minerals such as phosphoric acid; decalcium phosphate and sodium acid pyrophosphate, form rock phosphate
- Utilization of mine waste
- Development of Industrial process to improve the quality of minerals i.e., purification, polishing etc.
- Development of the mining equipment and machinery locally
- Development of real-time mineral content sensors for all minerals
- Design & Development of mining methods to reduce waste

Recommendations

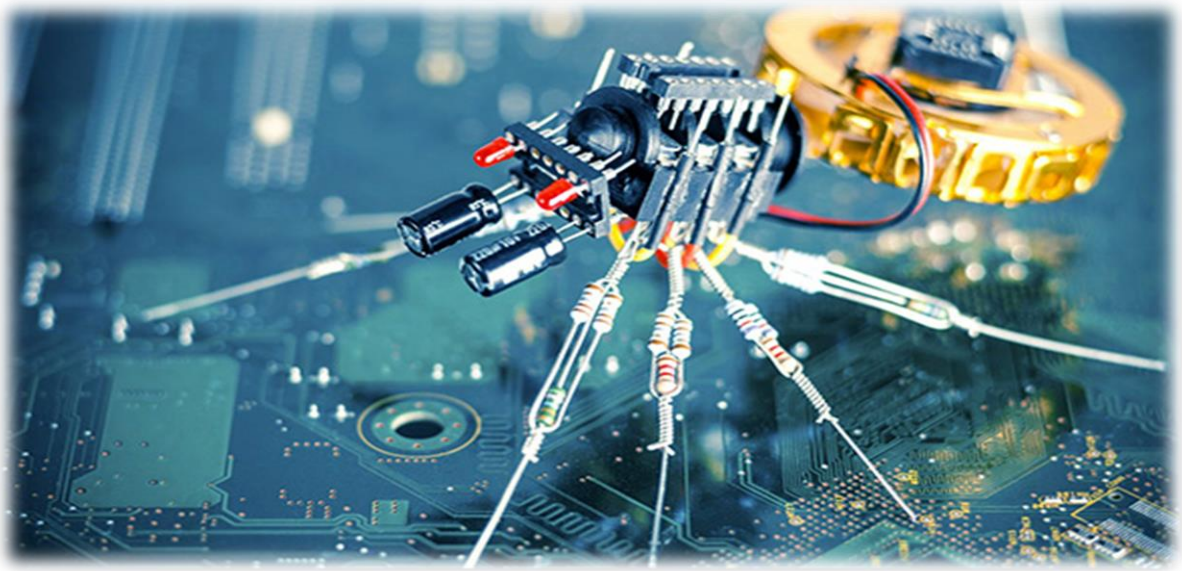
- On the basis of studies carried out by internationally recognized agencies the government may like to enhance the share of mineral sector upto 3% by 2025.
- Explore potential areas for finding new mineral and gemstones deposits and exploit the known mineral deposits such as coal of Sindh, copper-gold bearing Reko Diq deposit of Baluchistan etc.
- Industrial minerals, especially having sedimentary origin such as clays, salt, gypsum need to be studied / investigated for their possible use in the industry after necessary beneficiation/ treatment as import substitute.
- Need to focus on large-scale mining development through provision of an enabling regulatory framework, improved geological information and fiscal, revenue incentives.
- Exploitation of Thar coal on priority basis and available geothermal resources for use as alternative source of energy
- The value chain analysis for gems shows that 60% of the stones are damaged due to indiscriminate and uncontrolled blasting in the mines and only 25% of the gems are cut and polished in Pakistan. The majority of gemstones being exported from Pakistan is in rough form and is being cut and polished in countries like India, China, Sri Lanka and Thailand. The technology for gemstone mining needs to be upgraded and modern gemstone processing equipment for cutting and polishing of gemstones should also be introduced so that maximum quantity of value added products could be produced.
- Promotion of mineral based industry such as dimension stone, mineral based local jewelry industry, gemstone, aluminum industry etc. and development of rare earth elements, to enhance exports
- Feasibility studies may be carried out for establishment of Aluminium industry and development of rare earth elements.
- The Geological Survey of Pakistan should be given task to prepare commercial dossiers, on the mineral deposits of Pakistan. Furthermore the geological, geophysical and geochemical maps of Pakistan need to be updated and geoscientific information needs to be improved to attract foreign investment.
- To enhance local and foreign investment in mining/mineral industry sectors, detailed evaluation (of the reserves, grade, value added industrial applications, mining and processing methods etc.), revamping laws (based on internationally accepted legal system) and an enabling environment (security of investment etc.) is required.
- Linkages between Universities, R&D organizations, and the industry need to be strengthened to pass on the benefits of the R&D and innovation to the industry.
- PCST may constitute an Expert Panel in the Mineral sector and carry out Technology foresight exercise to give recommendations for making plans and strategies for the short to long term development of the sector.
- Higher studies in important fields of mineral sector at university level (e.g. Masters and PhD level degree programs in gemology) need to be introduced in universities.
- Setting up institutions/ labs with qualified human resource in the mining areas
- Institutional strengthening and capacity building for the departments of mines and minerals, both at the federal and provincial levels
- Industries may be set up in areas/localities having large deposits of mineral resources; however before planning such development, studies may also be carried to learn from the past and best international practices in this regard.

- Recently, dimension stone sector has witnessed encouraging technological interventions and projects introduced by Pakistan Stone Development in Balochistan and Manshera Granite owned by a private company are good examples of improved mining techniques. The same need to be replicated in other localities as well.
- The National Mineral Policy of 2013 need to be implemented in its entirety. Furthermore, if needed, the current minerals policy may be reviewed to make it more investment friendly and in line with the best international practices in consultation with the federating units, stakeholders and concerned organizations.
- The legislation, like Mines Act, and Regulations and made under this Act are quite old and need to be made compatible with present trends worldwide in terms of health and safety of people working in this sector and to keep minimum quality standards of products produced through mining.
- Need for provision of soft loans, sustainable fiscal incentives for undertaking development activities in the mineral sector through initiatives such as establishment of mineral development bank.
- Improvements to the mining tenement management system, GIS and implementation of social & environmental factors to ensure mitigation of mining related impacts.

Potential Socio-Economic Impact

The effective utilization of minerals resources would result in socio-economic growth, including opportunity of employment in remote areas. Promoting gem industry, dimension stone etc. could earn foreign exchange. There is also potential of value addition of salt products including health resort.

9. Nanotechnology



Problem Statement

Nanotechnology is said to be the technology of the 21st century. Scope of its potential applications expands across all sectors; ranging from medicine to industry, from environment to cosmetics and from agriculture to new materials. Realizing the importance of Nanotechnology, the Government of Pakistan has made investments for the development of nanoscience and technology network in the country. However, despite an impressive increase in the number and quality of research articles in the field of nanoscience and technology in Pakistan, there is no real evidence of translation of such research into marketable products as yet.

Present State of Development

Acknowledging the importance of nanotechnology, a National Commission on Nano-Science and Technology was constituted in 2003 which is now defunct. On the recommendation of this Commission, Ministry of Science & Technology approved 05 mega projects worth ~ PKR 900 million in the field of Nanoscience& Nanotechnology to establish nano-materials research facilities and manpower development programs at various universities and R&D institutions. In addition, HEC also approved a few larger projects at QAU and PIEAS (worth over PKR 60 million each) and many smaller projects (worth up to PKR 20 million) in this field in several universities and R&D organizations in Pakistan. These initiatives led to the development of reasonable research facilities for nano-science and technology in the universities/R&D institutions especially CIIT, QAU, PINSTECH, PIEAS, NIBGE, PCSIR, Punjab University, and many other organizations (notably ICCBS, GIKI, Peshawar University and NCEAC, Jamshoro, LUMS, Lahore, PINSAT, Islamabad). This has resulted into a significant increase in the number of research articles in this field, however, impact on economy is still not visible.

Relevance with the Pakistan Vision 2025

In the statement of the Prime Minister included in the Vision 2025, it has been acknowledged that investment in emerging technologies including nano-technology is instrumental in the creation of core competencies that can provide needed skills and enhance productivity to transform agriculture, industry and the service sector over the coming years.

Focus Areas of Research

- R&D for utilization of nanotechnology for:
  - Improved industrial processes
  - Nano-biomaterials for health applications
  - Defence industry
  - Remediation of the environmental problems
  - New and better solutions of energy problems
  - Food and Agriculture
- Development of Biosensors and Molecular Probes
- Synthesis of nanoparticles from medicinal plants, insects and microbes to be utilized as antimicrobial agents
- Development of nanoparticles as Drug Delivery Platforms for cancers, immune disorders, infectious diseases, etc.
- Catalysis and nanofabrication

Recommendations

- Revival of the National Commission on Nanoscience& Nanotechnology and its legislation.
- Setting up of National Institute of Nanoscience and Nanotechnology with State-of-Art equipment
- Revision of the curriculum at college and university level to introduce the courses of nanoscience and nanotechnology.
- Consortia of research groups and industry working in similar fields and their regular meetings to share/evaluate the progress of the working groups.
- Focus on the specific problems of local industries, particularly the export oriented industries, to help improve the quality of their products.

Potential Socio-Economic Impact

Nanotechnology is an emerging field, however, it is already helping to considerably improve, even revolutionize, many technologies and industries such as information technology, energy, environmental science, medicine, homeland security, food safety, and transportation. R &D in this sector can play a vital role to uplift socio-economic conditions.

10. Housing

Problem Statement

The estimated annual population growth rate of Pakistan is 2.10%. The current estimated population of Pakistan is 194 million, of the total population; the urban population constitutes about 36.2%, and is increasing at a rate of 2.6% per year. The level of urbanization in Pakistan is the highest among the East and South East Asian countries which is 38.8% in 2015. Pakistan current urban population growth rate is 2.81%.

Housing and construction sector is among the identified sectors by the government as the driver of economic growth. It is assumed that about 60 industries are directly or indirectly linked to construction & housing sector. Pakistan has faced the challenges of urbanization and inadequate housing due to migration of population from rural to urban areas since last two decades. Rapid population growth, over-crowding, shortage of supply, aging housing stock, development of slums and Katchi Abadis, scarcity of land and lack of financial resources has further aggravated the situation. The availability of affordable housing in affordable prices in proximity of mass transit and linked to job distribution, has become severely imbalanced in this period of rapid urbanization and growing density convergence. The cumulative shortfall in supply of houses equals 8.0 million units and is expected to reach the 10 million figures by the year 2020. The ratio of housing cost to incomes is much higher in Pakistan than in most other countries. Lack of adaptation of innovative technology (energy conservation, natural disaster resistant, smart materials, etc) and materials and lack of support to the research carried out in this field resulting in extravagant and skewed investment patterns in constructions and unreasonably high construction costs. Housing problem has further worsened because of weak regulation.

State of Development

Housing and construction is an important and growing sector of the economy of Pakistan. It is one of the fortunate sectors in Pakistan that has gained major relief in the Federal Budget 2015-2016. Pakistan spends about $5.2 billion on construction annually. Cities contribute 78% to the country's GDP (World Bank, 2016).

There is an annual shortfall of 270,000 housing units at present in addition to the backlog of around 9.0 million units. The current housing deficit stands at 5.11 million housing units. Given the rate of population growth and demographic changes in the age and marital status profile, incremental demand is estimated at 570,000 units each year. Out of this, only 300,000 units are provided, while 270,000 units are added each year to the accumulated backlog.

Mere access to housing is not necessarily a guarantor of adequate or quality housing, as even those with access to housing may suffer from congestion and lack of basic facilities. This is indicated by the fact that 37.6 percent of the population is still living in a housing unit with one room and only 28.3 percent of the housing units have independent toilet facilities. The level of congestion in terms of persons per room per housing unit goes a long way to reflect not only housing conditions, but also a general standard of living. There have, however, been improvements in other respects: 37.6 percent as opposed to 51.5 percent of the total number of houses have only one room, and 57.7 percent as opposed to 44.8 percent comprise units with two or more rooms. It is to mention here that even available housing facilities are not fulfilling recommended international standards of housing.

Relevance with the Pakistan Vision 2025

Pakistan Vision 2025 aims at transforming our urban areas into creative, eco-friendly sustainable cities through improved city governance, effective urban planning, efficient local mobility infrastructure (mass transit systems) and better security to make urbanization an important driver of growth. Vision 2025 seeks to ensure that Pakistan's cities are digitally connected, equipped with wireless network sensors and there is e-connectivity in all parts where the free flow of information is possible, thereby laying the foundations for the cities of Pakistan to be smart and creative.

Focus Areas of Research

- Energy conservation / management
- Environment friendly (eco-friendly)
- Information Technology (digitalization)
- Natural disaster resistant
- Building new materials / smart materials
- Cost effective construction and housing
- Water and waste management

Recommendations

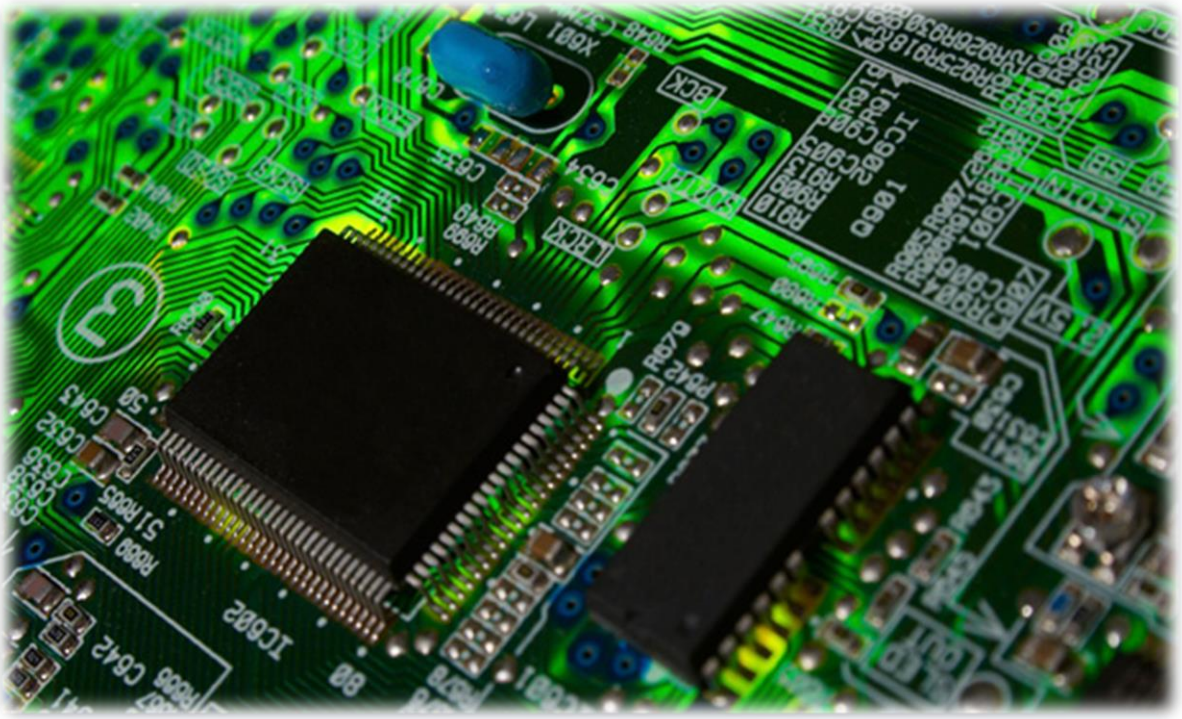
- There is a need to rationalize and simplify planning & building standards and procedures.
- Urban areas should be transformed into creative, eco-friendly sustainable cities (smart cities).
- A 'Housing information system' to provide data on housing demand and supply should be established.
- National housing policies need to be revised keeping in view the global trends & opportunities

- Digital system of security needs to be established at national level.
- City cluster development
- The construction and housing regulations should be implemented strictly.
- International standards of construction should be modified in local scenario.
- Land disposal and regulation mechanisms need to be developed.
- To cut down usage of private transport in urban centers, public transport including mass transit systems should be devised and implemented.
- Initiation of Housing Price Index (HPI) and Housing Access Index (HAI) through the assistance of Federal Bureau of Statistics.
- Development of a Housing Resource Centre at district level.
- Institutes for R&D on construction & housing should be established at national level.
- The centers of excellence in urban planning should be established in major cities of Pakistan.
- House Building Finance Company (HBFC) needs to be overhauled to make it a potent and creative organization.
- The CWHR needs to be strengthened in terms of research facilities and manpower.
- Initiation of Transferable Development Rights (TDR).
- Revision of urban housing density standards.
- Initiation of urban re-development on the pattern of mixed land use.
- Digitization of the land registration system at national level
- A regulator body should be established to register all property dealers.
- Adequate protection and maintenance of heritage sites and buildings in urban centers should be ensured.
- Smart cities council should be established at national level.
- Smart cities authorities should be established at provincial levels.
- Community based participation should be promoted to transform our cities into 'creative and innovative' cities.
- The accelerating rate of urbanization in the country requires urban planning and hence an effective management of the real estate market.
- Measures should be taken to develop rural areas for de-urbanization.
- Data management system should be established at divisional level.

Potential Socio-Economic Impact

Pakistan's cities contribute 78% to the country's GDP. In developing countries, including Pakistan, a 1% increase in urbanization leads to 1.1% increase in the economic growth rate. Housing not only provides physical shelter but also has significant impact on the lives of the dwellers in terms of skills enhancement, income generation, increased security, health, self-confidence and human dignity, and also result in boosting equitable economic growth and reducing poverty.

11. Electronics



Problem Statement

Electronics plays an important role in every aspect of modern human life. Almost all the developed countries have their economies depending heavily on electronics sector which is the world's largest industrial sector with an annual turnover of US$ 1.5 trillion. In Pakistan, electronics industry has a very minor share in the overall industrial output which is only about 3 percent. While the Large Scale Manufacturing (LSM) sector itself accounts for only about 13% of GDP. It is evident that there is a huge room for improvement in the electronics sector in Pakistan and without a strong growth in the electronics sector, goal of becoming one of the top 25 economies of the world cannot be materialized. A strong electronics industry will also lead to development of other industries and increase in productivity.

Present State of Development

The electronics industry in Pakistan is very small and it mainly depends on import of electronics equipment. Pakistan's annual imports of electronics equipment are worth $1.8 billion from China, $189.4 million from US, $77 million from UK and $54 million from Japan. Which shows that there is maximum room for saving foreign exchange in this sector. The existing electronics industry in Pakistan can be broadly grouped into five categories i.e. defense, industrial & automation, communication, technical services and consumer electronics. Growth in the sector is being hampered due to non-availability of raw materials and properly trained technical manpower as well as smuggling and import duty structure. Subsidization of the raw materials, creating demand for trained manpower and, locally manufactured electronics equipment will help to rectify the situation.

Relevance with the Pakistan Vision 2025

Electronics sector will have to contribute in a big way if we wish to achieve the goal of becoming one of the largest 25 economies in the world by 2025. It can make significant contributions in meeting targets of the Vision such as increasing annual exports from US$ 25 billion to US$ 150 billion, increasing annual Foreign Direct Investment from US$ 600 million to over US$ 15 billion, increase tax to GDP ratio from 9.8% to 18% and reducing poverty level by half.

Focus Areas of Research

- Designing and manufacturing of Chips, semi-conductor, integrated circuits and of high frequency Printed Circuit Boards (PCBs)
- Automation, Embedded and Industrial Control System
- LED Based Systems, Opto-electronic and Laser Technology
- Development of Solar Power Systems and Energy-efficient Products
- Telecommunication Security & Access Control Systems
- Space Electronics
- Standardization and Conformity Assessment.

Recommendations

- R&D in electronics may focus on developing technologies for use in the fields of manufacturing, communication, health, agriculture, security, energy, environment and education.
- Strengthening of relevant public sector educational and research institutions.
- The electronics equipment being manufactured in the country should be able to get accreditation by conforming to international standards. It will boost exports and local consumption by ensuring the quality. Electromagnetic Compatibility (EMC) testing facilities will also be required.
- PhDs obtaining degrees in the electronics from abroad and returning to country may be facilitated to establish their own companies / design houses by providing initial financial support by the government.
- Vocational institutes need to develop superior skills in technician level manpower for adaptability, service, reuse and re-life of equipment.
- State institutes should invest in the development of technologies with a long term vision.
- Defense projects be invited/assigned to universities, teams of scientists and engineers in the country on the model of ICT R&D Fund in Pakistan and Defense Advanced Research Projects Agency (DARPA) of United States.
- The government should lure foreign investors to establish electronics manufacturing industry while making sure that the technology transfer / deletion policy is implemented.
- Design and development of cargo scanners to reduce the import bill and enhance exports.

Potential Socio-Economic Impact

Development of electronics sector can contribute to growth and development of national economy in multiple ways such as import substitution, increase in exports, creating more job opportunities, reducing poverty and hence increasing total national GDP.

12. Space Technology

Problem Statement

Several Asian countries have space programs and are actively competing to achieve scientific and technological advancements in space. China, India and Japan are considered as the major players in the area of space technology whereas Iran, Israel, North Korea, South Korea, Pakistan and Bangladesh are considered as the minor players.

Historically, the space race' between the United States and the Soviet Union was all about national security. But now the acquisition of space technology means much more than that as future is for those who can develop and use space technologies for various purposes including intelligence. Various applications of space technologies are generating billions of dollars of business for industries that provide satellite communications (VSAT business communication systems, mobile telephones and data, direct-to-home TV, satellite radio, wideband data services, etc.), remote sensing (including mapping, agriculture, resource management, land use, etc.), and a growing set of industries that provide positioning, navigation, and timing services based on the Global Positioning System (GPS) and other related capabilities. It has been estimated that these services provide over US $65 billion of value around the world annually. Presently, Pakistan is not deriving any real benefits from this global business because of lack of capabilities and capacities in space technology.

Present State of Development

Realizing the importance and need of Space Technology in the modern age, Pakistan Space & Upper Atmosphere Research Commission (SUPARCO) was established to execute space programmes. Then, a Space Research Council (SRC) was established to oversee and formulate

policies for Pakistan's Space Programme. This was further extended to include Satellite Research & Development Center, Satellite Ground Control Station, National Center for Remote Sensing and Geo-informatics, Remote Sensing and GIS Labs, Pakistan Mission Control Center (PMCC) and Local User Terminal (LUT) for COSPAS-SARSAT International search & rescue programme, Ionospheric Research Station (IRS), Geomagnetic Observatory, Space & Atmospheric Research Station and a Geomagnetic Observatory. Pakistan launched its first sounding rocket Rehbar-1 for upper atmosphere research in 1961 becoming the third nation in Asia and the tenth in the world to launch such a rocket. It later developed sounding rockets indigenously. SUPARCO also developed two experimental satellites Badr-1 and Badr-B which were launched in 1990 and 2001 respectively. Later, work was undertaken on development of prototype communication and remote-sensing satellites. Development of Paksat-1R communication satellite in collaboration with China and it was successfully launched on 12 Aug 2011 from Xichang Satellite Launch Centre in China. Research and development work on SRS applications to meet Pakistan's specific needs has also been undertaken by SUPARCO.

Relevance with the Pakistan Vision 2025

The Vision 2025 does not mention space technology; however, in the modern era the applications of space technology are revolutionizing the daily life of people, therefore, developing capabilities in this important sector cannot be overlooked. Further, the applications of space technologies can help achieve Vision goals in the areas of food security, energy, communications etc.

Focus Areas of Research

- Space Technology for Disaster Management
- Launch Propulsion Systems and In-Space Propulsion Technologies
- Robotics, Tele Robotics, and Autonomous Systems
- Communication and Navigation
- Science Instruments, Observatories, and Sensor Systems
- Modeling, Simulation, Information Technology, and Processing
- Satellite ground equipment and software
- Development of the satellite bus and Payload designs
- Development of space launch vehicles for satellites

Recommendations

- To develop a national level consensus, at the highest forum, for space programmes' funding compatible with the expected outcome.
- Setting up a Space Corporation with the involvement of SUPARCO to coordinate and harmonize the commercial potentials of the national space programme in coordination with international space programmes through optimal utilization of technologies and human resource potentials.
- Government may consider ten years tax break for space segment related ground equipment manufactured or software produced in Pakistan. It will give incentives to

establish companies to set up their plants in Pakistan, and local entrepreneurs to make ground equipment in Pakistan.

- Establishment of satellite development centre.
- Establishment of Space Technology Park.
- To align the pace of space technology and diverts with endeavors.
- To develop pace delivery vehicles for LEO and GSO satellites.

Potential Socio-Economic Impact

Enhanced capabilities in the space technology would not only ensure national security but it will also positively impact the socio-economic condition of the nation through various emerging applications of space technologies.

13. Marine Resources

Problem Statement

The ocean and its resources are increasingly seen as indispensable in addressing the multiple challenges the planet will be facing in the decades to come. Fish is considered as one of the best source of quality proteins with valuable health benefits. By mid of the current century, much more food, jobs, energy, raw materials and economic growth will be required to sustain the significantly increased population in Pakistan; likely to swell to 344 million by the year 2050. Pakistan's Marine Sector with its vast area and resources has an immense potential in contributing towards meeting those requirements and enhance national economic growth and progress. Despite having huge potential of fulfilling domestic fish requirements from own resources, we are importing $40million worth of fish annually. The potential of the ocean resources to help meet these requirements would have to be utilized.

Present State of Development

The marine sector is very diverse, and includes at least offshore energy, maritime transport and construction, marine fisheries and aquaculture, tourism, and environmental aspects. Marine resources sustain a diverse range of economic activities. Growing population and improving knowledge and technological capability in respect to the oceans will lead to increasing utilization of marine resources. Pakistan's marine territory covers 290,000 sq. km (EEZ 240,000+ CS 50000), and is equivalent to the area of Punjab Province. The high quality of the Pakistan's marine and coastal environment provides a major competitive advantage in the fields of marine food and tourism, in addition to a source of new drugs / medicines. The rough estimates indicate that the marine sector in Pakistan contributes a considerable amount per year to the economy and supports over 100,000 jobs.

The natural resources of coastal zone of Pakistan include about 0.369 million metric tons of annual fish landing, about 612,000 hectare of mangrove forest, considerable resources of

minerals, seaweeds and sea salt, and estimated 14-16 billion barrels of oil and about 16 trillion cubic foot of gas, promising potential for mariculture, industrial use and potential of the coastal belt for recreation, tourisms, and sewage / waste disposal.

The marine and coastal resources exploitation, with the exception of fisheries and forestry sectors in Pakistan, is at its lowest level. The oil and gas, minerals, transport, and tourism are not being exploited because of inadequate exploratory surveys and lack of infrastructure.

Relevance with the Pakistan Vision 2025

The Vision 2025 has identified Marine and Coastal resources as an important natural resource. R&D in the area of marine resources will support achievement of the targets 'triple labour and capital productivity', increase the number of tourist arrivals to 2 million' and 'increase annual exports from US$ 25 billion to US$ 150 billion'.

Focus Areas of Research

- Living and non-living coastal and marine resources
- Marine and coastal biodiversity
- Mangroves and seaweed resource potential
- Marine Biotechnology
- Coastal zone management
- Persistent organic pollutants in marine environment
- Ocean-based energy sources (wave, tidal, thermal conversion, salinity gradient, gas hydrates)
- Low cost technologies for desalination of seawater for large scale production of water for drinking, industrial use and small scale irrigation
- Exploitation of available seaweeds for fertilizer and manure as well as for medicinal purposes
- Impact of climate change and global environment on marine resources of Pakistan

Recommendations

- Mapping of oceanic resources including both living and non-living resources in the maritime Exclusive Economic Zone as well as under seabed for assessing the potential of their utilization.
- Establishment of Marine Remote Sensing Facility for strengthening ocean research.
- Development of sea-based aquaculture and fishery industry.
- Integrated Coastal Zone Management Plans be prepared and implemented.
- Managing marine resources on an ecosystem basis to conserve marine biodiversity.
- Enhancing the existing fish processing capacities in the private sector.
- Capacity building of fisheries departments and fisheries managing institutions is the foremost requirement to promote 'mariculture' in the country.
- Government should declare the recommended sites by the experts as Marine Protected Areas.
- Promote and support marine resources entrepreneurship.

Potential Socio-Economic Impact

The successful and appropriate utilization of the marine resources would result in socio-economic growth of coastal communities, development of fisheries sector, enhanced tourism, development of coastal and marine infrastructure, and hence poverty reduction, especially on the coastal areas as well as decreased import and increased import of fish, earning valuable foreign exchange.

14. Automobile

Problem Statement

The overall performance of Pakistan Automotive Sector has been unable to meet its true potential even motorcycles are not manufactured indigenously except the assembling. The reason for low performance automotive industry may be attributed due to lack of infrastructure, bad governance and absence of friendly industrial policies. Car assemblers, with very few exceptions, are using technology and providing features lesser as compared to similar cars in the global market. In the small car segment, the technologies being used are obsolete and have been phased out in the global market. Domestic consumers are also being deprived of best available technologies and basic safety considerations like air bags, ABS etc. Manufacturers continua to rely on fuel-inefficient technologies leading to resort to alternate cheaper fuels whereas engines are not so designed, thereby burdening the consumers further. The existing market segmentation has allowed only assembly of cars to operate within closed, captive market which offers restricted options to buyers. Hence, the vehicles assembled in Pakistan are not upto consumer satisfaction, safety standards and environmental compliance continua short fall of expectations. Even prices of small cars are very high as compared to our neighboring country India, e.g. prices of small (800-1000 cc) cars in Pakistan ranges from 7200-11500 USD while in India ranges from 3500-5800 USD.

Present State of Development

The automotive industry of Pakistan is considered as one of the thriving industrial sectors of the country. It has large potential to grow, contribute towards GDP and exports as well as provides an opportunity of growth due to its forward & backward integration. Auto industry is the second biggest tax payer in the country. According to recent statistics, it has contributed 63 billion Pak rupees as indirect tax in the national exchequer (Economic Survey of Pakistan 2015-

16) and total contribution of Auto industry to GDP is 2.8%. Presently, auto sector is contributing 16% to the manufacturing sector. Around 2000 auto parts manufacturers (out of which around 400 are in organized sector) in the country that supply parts to original equipment manufacturers (OEMs). Besides that, automotive industry of Pakistan is providing employment opportunities to thousands of people all across the country. Currently, over 192000 people are directly employed by manufacturers with total investment 1.5 billion US dollar.

Pakistan automotive sector comprises assembly and manufacturing units for production of cars (3 units), tractors (8 units), trucks / buses (10 units), Jeeps (2 units), LCVs / pickups / vans (8 units), two / three-wheelers (113 units). In addition, the downstream vending industry comprises around 2000 parts manufacturers. Some of the leading world automakers have established their assembly plants in the country which are helping in the transfer of latest global technology to Pakistani industry. Besides that, various international auto companies, including Toyota, General Motors, Honda, Suzuki and Nissan Motors are in joint ventures with local companies. Currently, our automotive industry is largely dominated by three major companies which include, Indus Motors, Honda Atlas Motors and Pak Suzuki. All these companies have comfortable position in the market and have made in-house investments in sheet metals and plastic component manufacturing too. In the cars segment, Japanese manufacturers share the entire market, whereas their share are 41%, 69%, 62% and 96% in production of motorcycle, buses, jeeps and LCVs, respectively.

Relevance with the Pakistan Vision 2025

Automotive sector will have to contribute in a big way if we wish to achieve the goal of becoming one of the largest 25 economies in the world by 2025. It can make significant contributions in meeting targets of the Vision such as decreasing heavy import bill and increasing contribution in GDP from existing 2.8%, increasing annual Foreign Direct Investment (FDI) and reducing poverty level.

Focus Areas of Research

- Developing capacity for designing and manufacturing of engines & components including light & heavy vehicles.
- Designing for enhancement of visibility during driving.
- Light weight of engine units, components & sub-components.
- Increasing fuel efficiency of vehicles.
- Developing environment friendly vehicles to meet emission and safety regulations.
- Development of catalytic converter to reduce the emission.
- Conforming to national & international standards and practices.
- Standardization and Conformity Assessment.

Recommendations

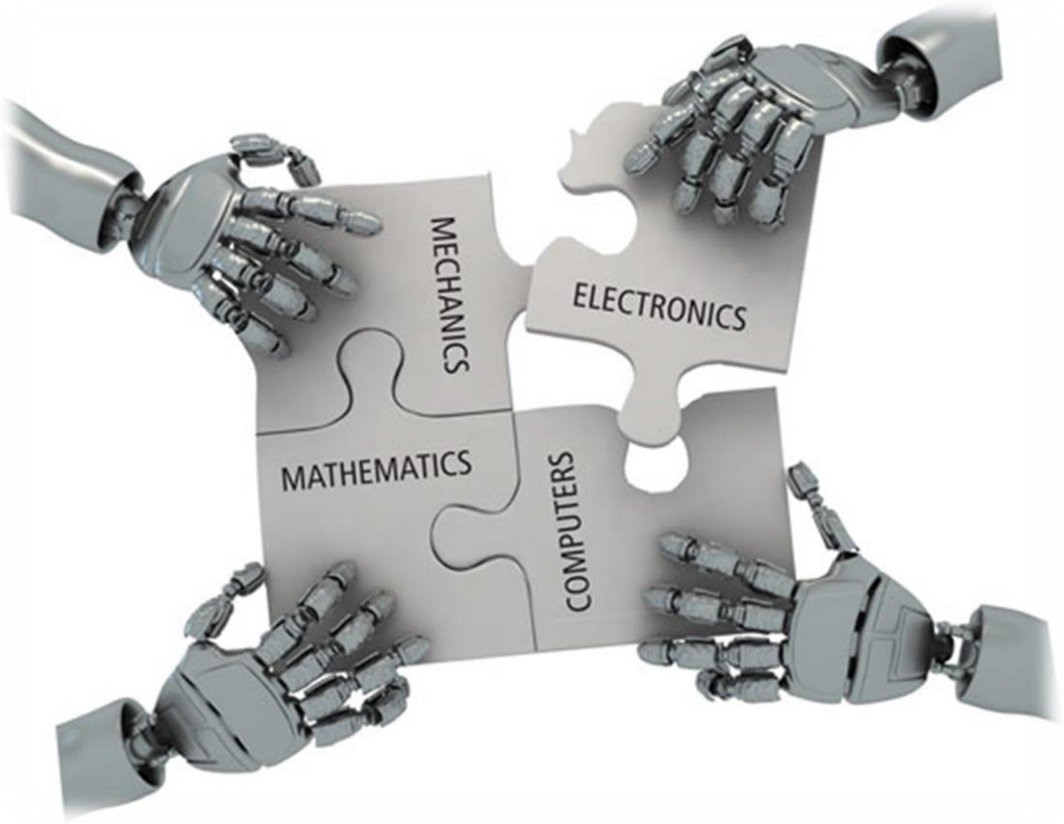
- Infrastructure regarding automotive design, testing and standardization may be established.

- Friendly industrial policies may be devised for uplift of automotive industry while keeping in view the local manufacturers as well as to attract foreign investors.
- Creating enabling tariff structure and mechanism for development of automotive sector.
- Automotive import policy needs to be rationalized.
- Regulatory & enforcement mechanisms for Quality, Safety and Environmental Standards (QS&ES).
- Establishing Technology development / acquisition & innovation Fund.
- Customers Welfare (CW) may be ensured through provision of quality, safety, choice and value for money.
- Auto industry should be encouraged to procure new technologies and management system to increase efficiency and productivity.
- Establishment of Pakistan Automotive Institute.
- Establishment of Automobiles Design and Research Centre.
- Establishment of automotive and auxiliaries testing labs.
- Auto clusters should be developed.
- Re-organization of Auto Industry Development Committee (AIDC).

Potential Socio-economic Impact

Development of automotive sector can contribute to growth and development of national economy in multiple ways such as import substitution, increase in exports, creating more job opportunities, reducing poverty and hence increasing total national GDP.

15. Robotics



Problem Statement

Pakistan's efforts in the past in bringing about what the world deems as the "fourth industrial revolution" to its industries have been dismal. However, in recent years, research laboratories in the leading private and public universities in the country have started to actively take initiatives in sowing the seeds of industrial automation in Pakistan. Efforts need to be expedited in effecting this technological revolution in the country. Through automation of industry, we may revolutionalize our industry to meet goals by 2025.

It was back in 1939-1940, during the New York World Fair that the first humanoid robot was exhibited. Since then, there has been continuous research and development in the area of robotics, world over. In Pakistan, the field of robotics is being explored by many private organizations, universities, incubators, startups and freelancers, are contributing in robotics from grassroots to advanced level. Robotics is being taught as a subject in multiple public and private academic institutions, along with few research groups have been engaged in robotics research. However, it is still in embryonic stage as compared to other countries of Asia such as Japan, China, India, Singapore and Malaysia. Pakistan is importing hardware used for fabrication in house robots. The facilities of design fabrications are rear in the country so for every redesign or change in approach introduce huge delays in finalizing the hardware. Lack of skills / expertise in robotics is one of the hampering reasons in developing indigenous robots.
Present State of Development

Since past couple of decades Pakistan took initiatives in developing robot's industry in the country with several startups, organizations, research groups, universities and incubators. Pakistan has been able to develop programmable logic controllers for use in automatic industrial controls having applications in the manufacturing industry. Both NUST and CIIT are extensively working on visual guided robotic systems for use in surgery, navigation control, mapping and geometric representation of environmental parameters. NIE, LUMS and CASE institutions are also engaged in research on Robotics and Artificial Intelligence. The National Engineering and Robotics Contest (NERC), is the biggest robotics contest held annually at national level.

The government is spending in design & development of intelligent mobile robots for disaster management and firefighting, development of tele-surgical training robot and simulator, and myoprosthetic upper limb. RoboMinors, Robokids and STEMERS are the leading startup companies that are promoting awareness on robot and its applications.

In 2013 two indigenously built tactical drones, named Burraq and Shahpar, were inducted into Pakistan Army and Air Force. Robotics has even made its entrance in medicine and surgeries in Pakistan. Surgeons in the top healthcare institutes of the country have employed advanced 3D imaging to get a deeper understanding of the body and plan their surgeries precisely. The availability of robotic arms and exoscopes in operating theatres has enabled more targeted, less-invasive treatment for patients.

Relevance with the Pakistan Vision 2025

Application of robot in various industries will have to contribute in a big way if we wish to achieve the goal of becoming one of the largest 25 economies in the world by 2025. It can make significant contributions in meeting targets of the Vision such as enhancing productivity, quality, decreasing heavy import bill and increasing contribution in GDP from existing 2.8% and reducing poverty level. It will also help in defence as well as disaster management.

Focus Areas of Research

- Developing Disaster Management robots
- Developing Environment Monitoring & Surveillance robots
- Developing Medical and Rehabilitation robots
- Developing Marine and agriculture robots
- Automation of local industries
- Developing defence related robots

Recommendations

- Establish robot research and design labs in Pakistan
- Awareness about the importance of STEM education
- The centers of excellence in robot research should be established in various engineering universities.
- The investment on robot research should be enhanced.

- The government should allocate special budget for specialization in robotics (PhDs).
- Training programmes need to be initiated for capacity building of professionals.
- Widen the ownership of business capital to ensure equitable distribution of robots.
- The training session should be conducted for workers to be able to operate and monitor automotive technology and systems.
- Robot technology incubation centers should be established in various engineering institutions.
- National R&D Organizations with mandate to robot research should be established.
- National Robot Technology Park should be established.
- The multidisciplinary robot research institution should be established at national level.
- Establishing robotic technology development / acquisition & innovation fund.
- Establish effective linkages between academia and industry.
- Public and private partnership model may be promoted.

Potential Socio-economic Impact

The robotics industry in Pakistan is still in its infancy, however, trends around the world have shown that a proliferation of robots in industry and agriculture increase productivity, wages and total labor demand, but mainly benefit higher-skilled workers. All of this will, however, come at the expense of low - middle skilled and wage workers leading to income inequality.

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