Science and Technology in the OIC Countries

Goals, Priorities, and Actions, 2016-25

Science and the Ummah

Nurturing the Thinking Mind

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This is an exciting time for science technology and innovation (STI).

Its influence on the way we live and work and communicate with one another is enormous and a new relationship is emerging between science and society, whose morphology is as yet unclear.

The pursuit of knowledge and the new frontiers which follow naturally will witness an ever increasing impact on all of humanity in the 21st century.

We are all living longer because of scientific discoveries and the technology innovations which follow inexorably.

Mankind is on the threshold of settlements in space at the same time as poverty eradication is within our grasp.

Science is disruptive,
and flourishes in an environment of irreverence.

Science and technology offer the tools for making change
as well as managing it.

As Muslims with a great tradition of seeking knowledge
wherever it is available,

***Let us prove worthy of this great human enterprise*.**

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List of Abbreviations

CADD	Computer Added Drug Designing
CAGR	Compound Annual Growth Rate
COMCEC	OIC Ministerial Standing Committee for Economic and Commercial Cooperation
COMIAC	OIC Ministerial Standing Committee for Information and Cultural Affairs
COMSTECH	OIC Ministerial Standing Committee on Scientific and Technological Cooperation.
EEZ	Exclusive Economic Zone
GDP	Gross Domestic Product
GERD	Gross Expenditure on R&D
HPCC	High Performance Computer Centres
HR	Human Resources
IAEA	International Atomic Energy Agency
IAS	Islamic World Academy of Sciences
ICANN	Internet Corporation for Assigned Names and Numbers
ICT	Information and Communication Technologies
IDB	Islamic Development Bank
IP	Intellectual Property
ISESCO	Islamic Educational, Scientific and Cultural Organization
ISO	International Standards Organization
ITER	International Thermonuclear Energy Reactor
KPIs	Key Performance Indicators
MDGs	Millennium Development Goals
MDR	Multiple-drug-resistance
MENA	Middle East and North Africa
MW	Megawatt
OECD	The Organization for Economic Cooperation and Development
OIC	Organization of Islamic Cooperation.
OICSHPA	The OIC Strategic Health Programme of Action, 2014-2023
PGR	Plant Genetic Resources
PIRLS	Progress in International Reading Literacy Study
R&D	Research and Development
RE	Renewable Energy.
S&T	Science and Technology
SDGs	Sustainable Development Goals
SEAMEWE	South East Asia-Middle East-West Europe Fiber Optics Cable
2nd TYPOA	OIC 2nd Ten Year Plan of Action, 2016-25
SESRIC	Statistical, Economic and Social Research and Training Centre for Islamic Countries
SMEs	Small and Medium Enterprises
STEM	Science, Technology, Engineering and Mathematics
TLDs	Top Level Domains
TYPOA	Ten-year Programme of Action, 2005-15; (Makah Al-Mukarramah, 2005)
UN	United Nations
UNCLOS	UN Convention on the Law of Sea
UNESCO	UN Educational Scientific and Cultural Organization
VISION 1441H	Vision 1441H for Science and Technology (10th Islamic Summit, Malaysia, 2003)

Science and Technology for the Ummah, 2016-25

Executive Summary

Science and technology will play a critical role in addressing contemporary challenges of development across multiple dimensions including poverty alleviation, better health, preservation of the environment, and ensuring food, water, and energy security, today and in the years to come.

Knowledge and critical thinking, of which science and technology are the most visible symbols, will be key drivers of change, not just in terms of economic growth and development, but in all human enterprise in this century, which includes creating change *and* managing the tools for change.

Recognising this imperative, the Twelfth Session of the Islamic Summit Conference, held in Cairo on 25-26 Rabi' al-Awwal 1434 H (6-7 February, 2013), mandated COMSTECH to organize the Summit of OIC Member Countries devoted exclusively to Science and Technology.

Earlier, the 4th Extraordinary Session of OIC, held in Makkah on 14-15 August 2012, had also underscored the need for adopting clearly-defined measures to promote and implement scientific and technological development and innovation, as well as the requisite educational infrastructure.

The Working Document prepared for the General Assembly of COMSTECH in May 2016 and its subsequent adoption by the Summit has drawn inspiration from Vision 1441H for Science and Technology enunciated at the 10th Islamic Summit in Malaysia in 2003, and the declaration regarding the Ten Year Programme of Action (TYPOA) by the 3rd Extraordinary Session of the Islamic Summit Conference in Makkah in 2005.

In addition, key OIC documents such as the OIC Strategic Health Programme of Action (OICSHPA 2014-2023) and OIC Water Vision, 2012- 2025 have been consulted, as well as the new Draft Document for the next TYPOA (2016-25).

This Document is the result of extensive consultations with 157 scientists and technologists from 20 OIC countries lasting seven weeks from November 2014 to January 2015. Their input and advice has been invaluable. The themes and guidelines for these consultative meetings are given in Annexure I.

Since the adoption of Vision 1441H, 2003, and the TYPOA (2005-15), encouraging advances have been registered in Member States in the fields of science, technology and higher education. This is reflected in the tripling of scientific publications and researchers, and major investments by several Member States in education and scientific infrastructure. However, the OIC countries generally lag behind other fast developing nations.

The Islamabad Declaration on Science and Technology will reaffirm the commitment of Member States to take further necessary actions for mainstreaming Science, Technology and Innovation (STI) in national policies and strategies, and fostering international collaboration for their promotion and advancement.

This Document has focussed on 'high technology' within the context of the ongoing global imperatives and the accompanying techno-economic-information revolution. This has resulted in a massive realignment and shift in centres of economic activity and relocation of manufacturing, services and design from developed to developing countries, globally and regionally.

The key features of this revolution are:

a. The nature of work and workplace is changing, leading to a 24 / 7 society.

b. SMEs (Small And Medium Enterprises) in emerging economies are evolving into global players offering complete end-to-end services in the supply chain.

c. Technological and organisational changes have reduced the relative demand for unskilled labour in developing countries since the 1980s. The skilled worker may actually be more sought after than the scientist.

d. New centres of power are emerging because of urban concentrations and growth of large cities, with completely different dynamics.

e. Major demographic transitions are taking place in the OIC Member States with important implications for health, and employability.

The OIC countries must leverage these profound shifts by adopting and using the framework of knowledge, science and technology.

Section I identifies some basic priorities for S&T for the period 2016-25 in OIC Member States. *These must be present before good science can be expected*:

a. *Nurturing the 'Thinking Mind': Build a Scientific Culture.* This is generally missing in most OIC countries. Science is nurtured by governments as much as the social norms of a country, which must be willing to embrace the pursuit of knowledge and it's accompanying disruptive impacts.

b. *Making People Employable: Education and Skills.* Every OIC Member State must now recognise that education is a "public good" and must therefore increase public investments at all levels, whether it is the university, secondary education, or technical and vocational levels. This will result in enhanced productivity in agriculture, industry and service sectors if firm arrangements are in place for offering different and higher skills which are certifiable internationally. Member States must aim for a minimum 15% enrolment in technical / vocational education among the 15-19 year age cohort, and national education budget levels of at least 8% by 2025.

c. *Security of Water, Food and Agriculture.* The Document reaffirms the recommendations of OIC Water Vision 2012-25 in maximizing the productive and efficient use of depleting water resources. It further recognises that the gene revolution is essentially over, and the poor and vulnerable in society will face further negative impact of extremes of climate change.

Food security and safety will be enhanced through better use of water, seeds, preservation of plant bio-diversity (National Gene Banks), and safety standards in the context of growing food processing, especially as regards Halaal Food. A key input for improved productivity and reduced spoilage will be extension of good agricultural practices and training which focuses on women who make up a large proportion of the rural workforce.

d. *Ensuring Healthy Lives for all Citizens*. This Document reaffirms the key features of the OIC Health Vision OICSHPA (2014- 2023). There is no good science without healthy citizens, who have universal access to health infrastructure, including clean water, medicine and vaccines. Targets include the following:

- Reduction of infant and maternal mortality to reach international norms; training and retention of paramedical staff and technicians as a priority; installation of robust early warning and response systems for detecting and containing infectious diseases and emerging viruses such as Ebola, and combating MDR (multiple-drug-resistance).
- Health budgets need to be raised to a minimum 10% by 2025 in lagging Member States in line with Sustainable Development Goals, 2016-25 (the OECD average is 16%).

Section II makes recommendations for multidisciplinary research in emerging areas of basic and applied sciences and technology. These offer major collaborative opportunities in frontier research and systems design. Chemistry, biotechnology, materials, computing, and ICT have major potential for economic spinoffs. Specific focus is placed upon:

i. *Improving the Quality of Higher Education* requires a shift in focus beyond simple expansion in student and faculty numbers, or publications, towards contemporary knowledge generation, excellent teaching, and expanded international linkages, in terms of student and staff exchanges and research. Universities must also bridge the cultural divide between social and physical scientists through broad based education. The target is for a minimum 50 Universities in Member States to be ranked among the top 500 globally by 2025.

Universities are known for their faculty and research infrastructure and researchers. The primary focus must therefore be on attracting and retaining the best faculty who are the 'long pole' in the tent of education through faculty development programmes, revised metrics for university rankings, harmonisation of accreditation standards across member States, and making universities financially sustainable. Technology parks will encourage entrepreneurship and help bridge the gap with industry.

ii. *The State of Research in OIC countries* is examined in terms of numbers of publications and patents which is an important proxy for innovation. Gaps are identified and actions proposed accordingly. It is observed that the basic sciences are generally neglected, although it is here that disruptive knowledge is actually created. This needs to be rectified. Specific actions are proposed in emerging areas of science and technology, while other recommendations for the period 2016 -25 include the doubling of annual expenditures on scientific infrastructure and R&D in those countries which spend less than 0.3% of GDP, with a target of 3% in relatively advanced countries.

Other targets include doubling the share of Member States in global scientific output (publications, prototypes and patents), and doubling the number of R&D workers per million population. It is further recommended to aim for a share of global exports of high technology goods and services in the economies and trade of OIC Member States to 8% by 2025.

iii. *Managing Big Data, Cyber Security in the Digital Economy* needs to be addressed on an urgent basis. Information and Communication Technology (ICT) is a major catalyst and enabler for socio-economic development, with strong footprints in many sectors. There are serious concerns for the security of digital content, which needs to be addressed.

The Document proposes several major actions, which include review of cyber security; curricula and delivery of IT education; secure intra-OIC high speed connectivity; and establishment of High Performance Computer Centres (HPCCs). The latter can be used for processing very large data, drug designing, and simulation and modelling of complex phenomena such as climate change. Excellent opportunities also exist for marketing, sales, and commissioning of IT projects /services across member states by harmonizing regulatory frameworks and IP laws.

iv. *Achieving energy* autarky *and managing the environment* is essential for economic well-being, growth, and sustainability. The broad goals will remain higher energy efficiency in *production and use*, and different energy *mix* with a target of at least 10% share of renewable energy by 2025, and research in storage technology and grid integration so as to facilitate large scale deployment of renewable energy.

Collaboration in peaceful uses of nuclear technology in power and non-power sectors (medicine, agriculture, and industry, etc) will be encouraged, consistent with respective international obligations of Member States and regulatory safety / security standards as enunciated by the IAEA (International Atomic Energy Agency).

v. *The challenge of climate change* has to be met on an urgent basis, with focus on protecting and preserving the environment, promoting sustained methods of production and consumption, and enhancing capacities for disaster risk reduction and climate change mitigation and adaptation. An OIC Expert Group on Climate Change is proposed.

Section III makes recommendations for some 'big' science programmes which will be executed and undertaken collectively by Member States. These relate to space, astronomy, oceanography, climate change and other activities. Apart from societal benefits, they offer major collaborative opportunities in frontier research and systems design and manufacture, in addition to offering cost sharing benefits. These are recommended as key enablers for building the knowledge economy and industrialising the economies of Member States.

Section IV examines mechanisms for enhancing intra-OIC and international cooperation, through 'Mother' / 'Lead' Institutes in different sectors of S&T. A major mobility programme is also proposed for scientists, researchers and students from the OIC countries.

- **The OIC Exchange Programme may be named as the Al Haytham Programme,** after the eminent scientist Ibn Al Haytham. UNESCO is celebrating 2015 as the International Year of Light, which is also the 1000th anniversary of his remarkable treatise on optics - Kitab al-Manazir. His methodology of investigation, in particular using experiment to verify theory, shows certain similarities to what later became known as the modern scientific method.

- **COMSTECH plans to organise an S&T Exhibition** during the Summit which will now be held in Kazakhstan 2017 in order to further improve linkages and knowledge sharing. This will be an excellent opportunity to highlight research innovation and products in the field of high technology.

Section V summarises the major programmes, their timelines for implementation and estimated costs. This will be firmed up after endorsement by the General Assembly of COMSTECH in Islamabad on 31st May-1st June for submission to the Summit:

i. *Research and Upgrade of Infrastructure* (US$ 1090 million). Funds will be used for upgrade of infrastructure and HR of universities and research institutions, pure research grants, mobility of scientists as part of S&T cooperation, training of scientific manpower, student research, etc. Beneficiary will provide 50% of funds.

ii. *'Big' Science Multi-National Initiatives* (US$ 835 million) These are joint multi-country initiatives and are expected to receive 50% funding from the countries themselves, such as small satellites for remote sensing. The national shares for a particular programme would be determined / negotiated by the partner countries.

iii. *Venture Funding and a Soft Loans Facility*. (US$ 160 million) is proposed to encourage high technology start-ups in emerging areas in order to bridge the academia-industry gap, and to enable existing technology based SMEs to grow into international 'Brands'.

iv. *Implementation Plan* : COMSTECH is developing in coordination with Member States, relevant OIC institutions and experts, a detailed Implementation Plan to cover specific programmes and activities, with clear responsibilities and mechanisms. It will include detailed cost estimates, timelines and Key Performance Indicators (KPIs), and will be implemented by a Steering Committee and its peer groups with members drawn from OIC States.

CONCLUSIONS: The COMSTECH Working Document is a Ten Year Plan of Action for OIC countries. It has been drawn up after extensive consultations with scientists and technologists from twenty Member States. It aims to sensitise governments, policy makers, and the public to partake wholeheartedly in the great game of the 21st Century – science and technology.

The Document is a natural extension of the Vision 1441H (2003), and TYPOA (Ten Year Programme of Action, 2005), as well as OIC Vision documents for Health (OICSHPA, 2014-2023) and Water (OIC Water Vision, 2012- 2025), and the draft TYPOA 2016-25.

This Document presents a holistic view of emerging science and technology, its multidisciplinary nature, and its social and economic spinoffs, as well as some big science programmes, which can be jointly undertaken by several countries.

The Document emphasises that science is disruptive, and flourishes in an environment of irreverence. Science and technology offer the tools for making societal changes, *and* managing them. *However, some basic ingredients must be present before good science can take root and flourish in a Member State*.

The Document also examines mechanisms for building collective competence in a wide array of themes ranging from water, food and agriculture to energy and the basic sciences and large multinational projects, in addition to strengthening international linkages with the best in the world.

SECTION I: Basic Priorities and Goals, 2016- 2025.

Meaningful collaboration among member states can take place only after good quality education and science is already available in these countries. Without this the desire for intra-OIC collaboration will remain a dream.

This Document fully endorses the goals and targets which are taking shape in the second TYPOA 2016-25, and suggests that these priorities and goals can and will be achieved by employing modern tools and methodologies, if the political commitment is present.

Four basic goals and priorities are identified which are currently being implemented with varying degrees of success in member states. These need to be strengthened further. Basic education, science, and skills as well as ensuring a healthy population and food security must be firmly in place in a Member State, *before* it wishes to undertake good science or engage in meaningful collaboration with other Member States.

Unfortunately, the OIC countries are generally lagging far behind their counterparts in the developed world whether it is literacy, or scores in mathematics and science, skills, and research or the budgets allocated for education (Annexure 2).

GOAL 1: Nurturing the Thinking Mind : Build a Scientific Culture

Notwithstanding some important gains in the past decade, a true scientific culture is conspicuous by its absence, whereas this is as an essential pre-requisite for any sustainable impact on society in OIC countries. Enough emphasis and attention is not given to the role of critical thought despite the fact that numerous verses in the Koran exhort believers to observe, think, reflect and think again[1]. There is a tendency sometimes to hail the earlier glorious period of Islamic science while ignoring the example of great Muslim scientists and philosophers, such as Al Razi and Ibn Rushd among others, who insisted that there is little value without critical thinking, reason and evidence. There should be no fears about the disruptive nature of knowledge and science, as this has been part of our heritage and traditions for centuries.

- **Recommendations :**
  - i. "Catch them young" at the school, so that critical thinking and curiosity can develop in young minds.
  - ii. Provide broad based quality education, which includes appreciation of one's own cultural heritage and that of others.
  - iii. Select teachers and curricula with care, especially the former.

GOAL 2: Making People Employable: Education *and* Skills.

Every OIC Member State must now recognise that education is a "public good" and must therefore increase public investments at all levels, whether it is at the university, the school, or technical and vocational levels. It is imperative to ensure universal and equitable access to education up to the secondary level *irrespective of gender*, coupled with major investments in development of skills and vocational training for the youth as well as adults. The aim is to enable decent employment with decent jobs and wages, leading to a new set of entrepreneurs.

[1] Chapter 3: Al - Imran, verse # 190

No OIC country matches the highest benchmarks in international competitive tests such as TIMSS[2] and PIRLS (Annexure 2), which points to poor quality of curriculum and teaching methods that are below international standards.

The quality of education imparted at secondary level, in science and mathematics, must be at the core of educational strategies of OIC countries. Enhanced productivity in agriculture, industry and service sector demands different and higher skills which are certifiable internationally. A better balance needs to emerge between graduate and post graduate education on the one hand and secondary education and skills development. There is a general consensus that proficiency in mathematics and science education as well as computer skills are essential for learning, generation of new knowledge and competitiveness.

International literature suggests that general education increases wages[3] The impact of a year of schooling on wages is estimated at about 10 percent and the average returns in countries with *low levels of schooling* range from 14 percent in the short run to 23 per cent in the long run[4] The productivity premium at the firm level for a trained worker has also been recently estimated from panel data in the OECD at 23 percent, with the wage premium of training being 12 percent[5].

- **Recommendations :**

  i. Ensure universal, equitable and inclusive quality education at the primary, secondary and tertiary levels and promote life-long learning opportunities that advance knowledge and skills needed for gainful employment, entrepreneurship, innovation and sustainable development. *Member countries may wish to link universal education goals to conditional cash transfers or social welfare programs in economically deprived areas*.

  ii. Remove gender disparities, with special attention to rural areas, where women tend to be a large portion of the work force.

  iii. Elevate STEM education (science, technology, engineering and mathematics), as a key priority at the policy level in OIC Countries, since future economic prosperity is closely linked with student success in the STEM fields. ICT and associated computer related skills must be made compulsory at all tiers of education.

  iv. Enhance opportunities for youth and adults to acquire relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.

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[2] *Trends in International Mathematics and Science* Study – TIMSS 2011, TIMSS & PIRLS International Study Centre, the Lynch School of Education, Boston, Mass.

[3] Card & DiNardo 2002; *Skill Biased Technological Change And Rising Wage Inequality: Some Problems And Puzzles;* NBER Working Paper 8769. *Also*: Barro, R.J. & Lee, J-W. (2010); *Int. Data on Educational Attainment Updates and Implications*; NBER Working Paper 7911.

[4] Soto, M.,(2002): *Rediscovering Education In Growth Regressions*, OECD Paper 202

[5] Konings J, & Vanormelingen S., 2010; *The Impact of Training on Productivity and Wages: Firm Level Evidence*, IZA Discussion Paper No 4731.

– Aim for a minimum of 15% enrolment in technical and vocational education among the 15-19 year age cohort in order to raise productivity in agriculture, industry and service sectors through different and higher skills which are certifiable internationally.
– Introduce modular one / two year vocational education / skills programmes in the secondary / higher secondary levels (9thth to 12th year of education).
– Focus efforts on rural area where young people and women need quality education and skills which can translate into more productive, efficient and sustainable farming, rearing of livestock, and related agricultural services.

This will also help in reducing migration from rural to urban areas.

v. Raise gradually the allocation for all tiers of education to a minimum of 8 percent of annual national budgets. Many OIC countries lag their peers in developing countries and within the OIC itself in spending on education.

GOAL 3: **Security of Water, Food and Agriculture**

Food safety and security is affected by several factors. *First*, the "green" revolution is essentially over and high growth rates in agriculture will not be sustained through current technology, practice and attitudes alone. *Second*, the use of genetically modified seeds is increasing. *Third*, climate change has increased the vulnerability of farming communities because of extreme weather patterns. *Fourth,* food processing is widespread, because of changes in life styles and urbanisation, which requires long shelf life of products.

Most OIC member states are running out of usable land and water, which is further exacerbated by climate change and its likely impact on food security. The urgency of this issue has already been highlighted in the OIC Water Vision which calls for all measures to maximise outcomes from the least amount of water, as well as achieving universal and equitable access to safe drinking water.

Vigorous implementation measures are needed to enhance sanitation, reduce water pollution and recover waste eater through efficient treatment. In addition, dumping of industrial and toxic wastes is required to be managed on an urgent basis. This covers the marine ecosystem which is facing extreme pressures.

The goal of increased water efficiency in all sectors including agriculture, industry and urban water courses will be pursued vigorously at all levels. This is essential to combat desertification, and reducing land degradation.

3.1 Productive Use of Water. This will be maximized in order to achieve higher crop yields with lesser water use by 2025. Special attention will be given to skill development and extension of research to rural communities, which provides an excellent opportunity to focus on skills for women who form a major part of the rural work force in most OIC countries.

Considerable expertise exists within OIC Member States, and local communities will be empowered through appropriate technologies in the areas of safe drinking water, hygiene and efficient water use / recycling. International cooperation and capacity building will provide additional measures to meet these needs.

- **Recommendations :**

    i. Prepare national water budgets so as to avoid growing water-intensive crops in water stressed areas. Modern scientific techniques are available for monitoring of aquifers, sub-soil hydrology and water loss in irrigation canals (~ 40 % of agriculture in Member States outside the tropics depends on canal irrigation).

    ii. Reduce the use of sweet water and improve yields through laser land levelling which results in uniform spread of water and fertiliser. Bio-saline agriculture is also a key domain that needs to be explored. Expertise, products and processes are available in Member States.

    iii. Expand water storage in countries where this can be done in order to exploit the positive aspects of global warming (higher precipitation is predicted by all models).

    iv. Finally, there is need for OIC to facilitate the preparation of appropriate integrated water resources management at all trans-boundary flows in order to minimise possibility of conflict of shared waters.

3.2 Food Security and Agricultural Productivity. This will be enhanced through the following measures:

i. Plant biotechnology will be employed for development of new seeds for food and cash crops, which are salt tolerant and also require less water.

ii. Plant Biodiversity will be strengthened through National Gene / Seed Banks for conservation and exchange of PGR (plant genetic resources) with researchers in member states. Considerable expertise already exists within member states for achieving the objective for biodiversity conservation.

iii. Cooperative programmes will be launched for capacity development and sharing of knowledge, expertise and human resources and indigenous horticultural genetic resources. This will result in improving livelihood of farmers – through value addition and reducing post-harvest losses through sharing and adoption of modern techniques, based on case studies

3.3 Food Safety: This will be enhanced by deploying biotechnology and modern science and which can provide effective solutions across the entire spectrum from the land and factory to the table. These will integrate the safety and security of the food chain by verification of hygienic, nutritional and organoleptic qualities, and apply to every participant of the food chain, from producers of animal feed and livestock breeders, to manufacturers, transformers, carriers, and distributors. It also covers manufacturers of packaging, additives, ingredients, cleaning products, as well as the producers of pesticides, fertilizers and veterinary medicine.

International Standards such as IFS (Food Safety initiative), BRC (British Retail Consortium), EurepGAP (European Retail Protocol for Good Agricultural Practice), and ISO 22000 (Food Safety Management System) need to be enforced rigorously.

3.4 Certification of Halaal Products.

The growing Halaal food market is valued at about US $ 2 to 3 trillion annually. The major interest here is authenticity and verification. All OIC countries are gradually adopting Halal food certification standards and verification. COMSTECH, in association with OIC institutions, subsidiaries and affiliates, will identify institutions which possess facilities for product testing and research, as well as expertise in food science technology and other related disciplines, and encourage sharing of expertise and best practices.

GOAL 4: Ensuring Healthy Lives for All Citizens

Together with education and skills, it is necessary to ensure that the determinants of effective public health are firmly in place to ensure health and well-being. This translates into equitable access to essential health care, quality and affordable essential medicines and vaccines for all, within the framework of robust public health systems capable of supporting world class health standards in the OIC countries, as enunciated in the OIC Strategic Health Programme of Action OICSHPA (2014- 2023).

- **Recommendations :**

  Ensure universal access to clean drinking water and sanitation. Implement measures for sanitation, reduced water pollution, recovery of waste water through efficient treatment, and managing the dumping of industrial and other toxic. This covers the marine ecosystem which is facing extreme pressures.

  i. Provide essential healthcare including financial risk protection. Focus on public health, with allocations of nearly half the health budgets.

  ii. Ensure reliable access to safe, effective, quality and affordable essential medicines and vaccines for all, and increase the capability for indigenous manufacturing and production of essential vaccines and medicines.

  iii. Reduce infant mortality ratio to less than 15 per 100,000 live births and preventable deaths of newborn and under-five children by 60%. This requires that we train and retain the health workforce in OIC countries, especially paramedics and technicians for maintenance of expensive equipment.

  iv. Set up national early warning and timely response systems for detecting and containing infectious diseases (TB, Malaria, HIV/AIDS), as well as collectively combating emerging viruses and epidemics (MERS, Ebola), or polio, tuberculosis, malaria, and other tropical diseases and combat hepatitis, water-borne and communicable diseases. This will require creating and sustaining a cadre of trained epidemiologists backed by an Emergency Command Centre.

  v. Confront the challenge of antimicrobial MDR (multiple-drug-resistance) and promote rational use of drugs as a public health priority.

  vi. Enhance collaboration between Member States and international partners for implementing the goals of the OIC Strategic Health Programme of Action (OICSHPA 2014- 2023).

  vii. Increase health financing to a minimum of 10% of national budgets by 2025.

SECTION II: Universities and Emerging Science and Technology

With the foundations of education and skilled healthy manpower firmly in place, it will be possible to focus on promotion of research in emerging areas of science and technology. This requires building up sustainable infrastructure in universities and research institutions, and preparation of programmes for building domestic innovation and technology capabilities in all sectors which can lead to economic gains also.

There are no Nobel Prizes for technology, only in basic sciences.

Basic sciences have quite often been neglected at the altar of patents and economic gains, even though these have unintended disruptive consequences for society at large. Research is unpredictable. *The basic theme of this document is therefore the promotion of multidisciplinary research while giving equal importance to basic and applied sciences.*

Several countries have developed and strengthened national policies in recent years and created reasonable enabling environments for scientific and technological advancement. However, despite major investments, quality of higher education and research intensity lags behind developed countries, except in a few countries.

1. Improve the Quality of Higher Education.

- **Goal: At Least 50 Universities for Inclusion in the Top 500 Globally by 2025.**

Universities are in distress everywhere. They have expended time and resources in modernising management systems and processes, which has tended to become market oriented, while neglecting academic processes.

University education needs to cross a certain quality threshold for excellence in research to emerge. Member states must move beyond simple expansion in student enrolment and faculty numbers or publications by transforming their universities into centres of excellence. The focus must shift towards contemporary knowledge generation, excellent teaching, and expanded international linkages.

While economic gains from modern science and technology are desirable and welcome, emphasis on economic benefits alone needs to be contextualised within the requirement for a sustainable scientific eco-system, whose dynamics can be different from those of mere technological and managerial innovation.

Simultaneously, we need to bridge the cultural divide between social and physical sciences by encouraging broad based education. This requires scientists and engineers to be aware of societal dynamics by making social science modules compulsory for scientists and engineers and vice versa. This can help bridge the divide. Moreover, we need to make both science students and social science students aware of some aspects of the history of science in the Islamic Civilisation as well as those who came earlier or followed them.

Some issues will be managed by each and every Member State itself in an environment of rapid growth in the higher education sector. OIC and COMSTECH can and only *supplement* these activities and policies, and cannot be a substitute for absence of national policies.

1.1. Brain Drain. There is a global race for men and women of talent who are sought eagerly by every nation. Institutions of higher education must work towards attracting and retaining top talent, and building partnerships to ensure top researchers have access to world-class research space which is internationally relevant.

- **Recommendations:**
  - i. Make faculty the 'long pole' in the tent of education and research and take time to build a critical mass and research groups around people in key areas, with improved service structures for faculty and researchers as well as financial inputs for individuals and their institutions, especially fresh PhDs.
  - ii. Review current faculty performance metrics, whereby a disproportionate emphasis is placed on publications and not enough on teaching or marketable skills for graduates. Globally, there is much discomfort at the race for publications, which hinders good teaching as well as research.

1.2. Accreditation and Equivalence. There is absence of accreditation and equivalence of education standards across OIC Member States for both public and private institutions, especially the latter which have increased their footprint in recent years.

- **Recommendations :**
  - i. Prepare a common accreditation framework for education in order to facilitate exchange of students across countries and make private institutions eligible for state partnership / partial funding especially for assistance for needy students.
  - ii. Set up regulatory and quality assurance institutions while maintaining institutional autonomy and discouraging education as business.

1.3. University Rankings. Rankings have become fashionable lately, and are useful or necessary for institutions of higher education in OIC countries to position themselves as leading global institutions. However, the process needs an overhaul, and a fresh ranking needs to be initiated regularly *after re-drawing* the appropriate metrics and evaluations.

1.4. Financial Sustainability. Universities must become financially sustainable in order to afford quality faculty and infrastructure. This cannot be done by exclusive dependence on government financing or student fees. Member states may consider returning to the traditional 'Waqf', whereby land is attached to madrassahs for some operational expenses. Oxford and Cambridge Universities, for instance, have the largest land holdings in UK after the state, whilst the size of Harvard's Endowment in the US exceeds the GDP of a small country at over US$ 30 billion. This is also the case with several land-grant universities in the USA.

1.5. Intra OIC Cooperation. There is very little mobility among faculty and researchers in OIC countries. There is urgent need to consolidate and expand the OIC Educational Exchange Programme through a special programme, which would promote exchange of students, faculty and researchers.

It is recommended to initiate an OIC exchange programme, called the Al Haytham Programme, **after the Muslim scientist Ibn Al Haytham, regarded as the father of modern optics. UNESCO has named 2015 as the International Year of Light, as well as the 1000th anniversary of Al Haytham's remarkable seven volume treatise on optics - Kitab al-Manazir. His methodology of investigation, in particular using experiment to verify theory, shows certain similarities to what later became known as the modern scientific method.**

In this context a total of 5000 scholarships are proposed by 2025 which may be offered by the top ten leading OIC countries, with special quotas for students from less developed states.

2. State of Research in OIC Countries:

The state of research in OIC countries can be gauged by the fact that 79% of the nearly 118,000 scientific publications in 2014 *emanated from just seven countries*[6]. During 2000-2014, nearly half the scientific publications emanated from just two countries (Turkey and Iran), and Pakistan had the largest growth. Patent applications are a proxy for industrialisation, entrepreneurship and research, but the share of OIC Member States[7] in the 2.34 million global patent applications filed in 2012 was only about 35,000 (1.5%). The share of 'residents' in patent applications was extremely small except for Turkey and Iran, indicating weakness in the local systems overall.

➢ **Recommendations :**

i. Promote networking and linkages within OIC and with leading world universities for research partnerships and sharing of knowledge and experience on quality control. The Ibn Al- Haytham Programme (section 1.6 above) will be extremely helpful.

ii. Encourage Technology Parks adjacent to leading universities in OIC Member States. This will promote linkages with industry and business.

iii. Invest in building up university departments and research institutes to the status of 'Lead Institutes' of the OIC in specific areas of science and technology.

iv. Double the annual expenditure by 2025 on scientific infrastructure and R&D in those countries which spend less than 0.3% of GDP, and aim for a target of 3.0% in countries which are at a relatively advanced level. This has to be accompanied by a programme of capacity building in personnel and institutions to avoid under-utilisation of available Gross Expenditure on R&D (GERD).

v. Aim for doubling the share of member states in global scientific output (publications and patents) in the next ten years.

vi. Double the number of R&D workers per million population (to include all levels of scientific manpower, including certified technicians)

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[6] COMSTECH data, based on *Web of Science TM Core Collection,* (Science Citation Index Expanded (SCI-EXPANDED, 1975-present). *Also* : COMSTECH: SWOT Analysis of OIC Member States, 2013;

[7] SESRIC, (Education & Scientific Development In OIC Countries 2014); See also: U.S. Patent and Trademark Office, 2013; Patent Applications in WIPO Geneva, 2013.

vii. Increase the share of high technology goods and services in the economies and trade of member states, aiming for 8% by 2025 from the current 3.8%.

viii. Harmonise intellectual property rights across the OIC Countries.

3. The Case for Mathematics and Physics

It is not possible to list all major activities in mathematics and physics. Apart from research at the frontiers of theoretical and experimental particle physics, astrophysics, cosmology, and astronomy, the trend in physics is for multidisciplinary research with biology, space, fusion, material science and computers coming together to create a complete new value set, including the development of exciting new measurement and characterisation tools for industry and the scientific community.

In materials, the greatest challenge is to understand and predict the broad range of materials that can be used in a wide range of applications. This provides a major opportunity to move away from high cost materials to cheaper ones, and the ability to conduct science-driven experiments to promote an integrated understanding of materials and their behaviour.

Nanotechnology, graphene and nano-tubes are some of the most conspicuous recent developments, and novel applications have emerged in the areas of energies of systems from the nano-scale to bulk properties.

Plasma physics has seen enhanced interest because of the construction of the ITER fusion facility in France as well as laser based fusion. A series of scientific and engineering breakthroughs could enable fusion to become a feasible a power source faster and cheaper than anyone had thought possible. Solar energy has also witnessed some impressive developments in light to electricity conversion even though this is still some years away from commercial exploitation.

Lasers and photonics have revolutionised studies at the interface of science and engineering. communication, laser-matter interaction, defence, precision machining, atomic and molecular spectroscopy, space-based instrumentation, non-linear optics, nano-photonics, imaging, and the ubiquitous CD / DVD.

At the theoretical level, mathematics and physics have always produced excellent science in areas of general relativity and gravitation, cosmology, particle physics, group theory and nonlinear problems. The true flavour of physics emerges when one adds the ongoing research into dark matter or why there is unequal amount of matter and anti-matter, or why some elements are heavier than others. It is interesting to note that a leading bridge designer in the world is a particle physicist from Argentina who used his particle physics background to switch over to a completely new field.

- **Recommendations :**

  i. Promote physics and mathematics at all levels in OIC countries, from the school to the university, since their rigorous foundations provide excellent applications in research and industry.

  ii. Focus initially on nurturing a nation’s domestic science, rather than collaboration between OIC countries so that strong groups and activities can emerge, thus leading to better chances for intra-OIC collaboration.

iii. Designate National / Regional Research Centres in physics as 'Mother Institutes' which focus on specific activities or broader subjects, and which can be shared by other OIC Countries. These include (but are not restricted to):

   – Mathematics and theoretical physics;
   – Astronomy; atomic, molecular, and plasma physics; synchrotron light sources for research in physics, material sciences and biological research;
   – Lasers from the continuous to the femto-second domain for diverse use, including medical applications and fusion studies.
   – Material sciences, nano-materials, and semiconductors.
   – Magnetism and superconductivity.
   – Design and develop teaching equipment and aids through an OIC consortium drawn from universities, research institutes, and industry for use in schools and universities. (this capability exists already in some countries and can be shared).

4. Biology and Biotechnology for the 21st Century

The 21st century will probably belong to biology and new materials, which now draw upon the opportunities presented by the coming together of biology, physics, materials, nanotechnology, mathematics, electronics and computers.

We are already witness to major advances and convergence in health and agricultural sciences, drug design and delivery, and instrumentation that is now classified broadly as biotechnology. This is having major impact on both academia and industry for biomaterials and bionics, imaging, molecular sorting and diagnostics, and biosensors, to name just a few.

The drug discovery paradigm has now shifted from the traditional hit and miss affair to Computer Aided Drug Designing (CADD) and optimization for target-based lead discovery to improve their bioavailability and biological activity. All this is triggered by the advent of software, new theories, and algorithms in a pharmaceutical setting.

Priority will be given to managing the challenges to human health which flow from increase in antimicrobial resistance as well as transition from infectious to chronic diseases (hypertension, diabetes, cancer).

As with physics, 'Mother Institutes' will be identified and promising research groups elevated to levels of excellence and made internationally competitive and capable enough to efficiently contribute towards achievement of specific goals and transfer of skills and technology to the less proficient member states.

- **Recommendations :**

   i. Confront the antimicrobial MDR (multiple-drug-resistance) challenge and promote rational use of drugs as a public health priority.

   ii. Expand research in infectious diseases (TB, Malaria, HIV/AIDS) as well as emerging viruses and epidemics and genetic disorders.

iii. Focus on infrastructure and human resources in biotechnology, which can provide appropriate solutions in medicine, pharmacy, agriculture and even energy.

iv. Establish drug discovery and development programmes in Member States with concomitant research capacity and development.

v. Establish six HPCCs (High Performance Computation Centres/regional facilities with national nodes) for work in structural and computational biology / bioinformatics, computational chemistry / molecular modelling, and design and synthesis of new chemical entities and drugs.

vi. Establish National / Regional Core Facilities in Biotechnology as these cannot be readily replicated in every university. These include modern animal research facilities with requisite bio-safety and containment facilities, and pre-clinical and clinical translational research facilities. These will regulate clinical trial facilities and bioavailability/bio-equivalence (BA/BE) laboratories in a member state and would include small-scale production and processing of bio-pharmaceuticals and biomaterials under GMP conditions.

vii. Support and leverage indigenous knowledge and medicine by combining strengths in traditional knowledge with modern molecular biosciences by collecting and preserving Regional Flora and Fauna / Biodiversity.

viii. Expand and prepare manpower for using the proposed regional multi-beam synchrotrons (see Section IV), as these are an excellent tool for multidisciplinary research in biological, medical, physico-chemical material and their applications.

ix. Initiate and expand research in the development of biomaterials, and biosensors (estimated market of US$ 16 billion in 2016).

5. The Chemical Sciences

The excitement in recent years is the application of the laws of quantum mechanics to molecular and chemical systems.

Computational chemistry and computational biology have emerged as new hybrid disciplines of medicinal chemistry. This has totally revolutionized the way we think about chemistry and biology. This has opened the possibility of manipulating atoms and molecules through computer aided design (designer molecules) to create totally new entities, systems, membranes, materials, and environmentally friendly devices.

Furthermore, about 85% of the chemicals produced require catalysts for their preparation**,** whether in refining, manufacturing or creating new polymers, with a market of over US$ 40 billion in 2012, and growing at an annual rate of 5.8%**.** Industrial enzymes are another major activity, projected to grow at a compound annual growth rate (CAGR) of 9.1% to reach $6 billion by 2016. There is also increasing focus on fuel cells, which are critical for energy storage.

Two major programmes are proposed in the chemical sciences:

i. Set up six Regional High Performance Computation Centres (HPCCs) initially across Member States which would be accessible to the scientists working throughout the

OIC regions, as emphasised earlier in the section on physics, mathematics, and biology. Some leading groups in OIC universities are actively engaged in this field, but all of them use facilities in developed countries. The components of sustainability and training would be an integral part of the proposed centres. Simultaneously, collaborations and strategic alliances will be established with centres in scientifically advanced countries.

ii. Assist academia and industry in Member States in research in industrial chemistry, catalysis, polymers, new materials and fuel cells as priority areas.

6. Big Data, Cyber Security and the Digital Economy

Information and Communication Technology (ICT) is a major catalyst and enabler for socio-economic development, with a strong footprint in many sectors where it can directly add value. These sectors cover public health, governance, security, law and order, defence, commerce, communication, supply chain in manufacturing and services, tourism and hospitality, and education.

ICT is also a unique factor in the emerging relationship between science and society in the 21st Century, whereby physical proximity is no longer necessary in making key decisions or in their implementation. This requires seamless matching of transnational skills, which can facilitate low cost solutions in developing countries that draw on all aspects of science and technology which are directly relevant to economic prosperity and technological advancement.

6.1 Greater Intra-OIC Connectivity

Providing full geographical coverage to citizens in the future inter-connected world of communication, commerce, industry and education is valued everywhere. Further, government departments and personnel to make a transition to e-government which will enable faster and more transparent decision making, in the context of greater demand for 'freedom of information'.

- **Three critical actions are required:**

  i. Connect OIC member states through secure, high speed, fibre-optic land and sea based networks, and satellite links, with built-in redundancy; or at least facilitate such networking for/with major world companies in this domain. *This would be a secure intra-OIC network in addition to SEAMEWE 3 and SEAMEWE 4, with service nodes within the OIC States.*

  ii. Update and review curricula and delivery of IT education, which is in a state of rapid flux, in order to bridge the academia / industry gap, including inducting trained ICT competent teachers in schools. This can result in a vigorous series of new entrepreneurial activities with major economic impact emanating from the premise that we need our young entrepreneurs in the Islamic world to lead in leveraging ICT for commercial benefit.

  iii. Encourage the ICT community to develop content for the Internet in local languages and facilitate collaboration between OIC companies in the different countries in the area of localisation (production of content in local language) of content.

iv. Set up and manage High Performance Computer Centres (HPCCs) to meet the growing need for processing very large data (meta data), whether for use in national databases for citizen identification, creating national repositories of health profiles, computational simulation and monitoring of climate change or physics, or for designing new chemicals or drugs, etc. Such HPCCs should be set up gradually in all OIC member states.

v. Finally it is recommended to encourage development of laboratory test equipment and bio-medical equipment which is driven by advances in computing power, (hardware and software), and which can compete with the best available in the market.

vi. Venture Capital Funds and Soft Loans for high-technology start-ups would be set up as explained in Section V. There are excellent opportunities in this area, if the requisite Intellectual Property Laws are harmonised across the OIC Member States.

6.2 Cyber Security.

Availability of wider bandwidth, cheap storage and easy access to the digital media and internet, with applications for social networking and personal management, has exposed the vulnerability of individual privacy and privileges.

- The following actions will be undertaken in concert with partners in member states, the OIC Secretariat, and OIC organisations, subsidiaries and affiliates:

  i. Review OIC CERT (Cyber Emergency Response) programmes and laws which need to be re-drafted and harmonized across Member States for digital security and protection of Intellectual Property. This will be undertaken by a cross-country task force (CCTF) which will look at best practices in leading OIC countries and manage their uniform adoption.

  ii. Facilitate easier marketing, sales, and commissioning of IT products and services across member states. This will be embedded firmly in a set of harmonized regulatory policies, frameworks and IP laws.

6.3 ICT and Social and Emotional Well-being of Children.

The internet is having an adverse effect on very young children. Awareness needs to be disseminated together with the tools to protect them from abuse and confusion through better parental control, and child online protection policies.

6.4 ICT and Top Level Domains (TLDs).

The COMSTECH Document recommends the protection of TLDs with Islamic identities at the Internet Corporation for Assigned Names and Numbers (ICANN) through a coordinated approach of all OIC Member States.

7. Managing Energy and the Environment.

The quality of modern human life has been and always will be completely dependent on the availability of affordable energy. There are serious concerns however, that consumption of water, land, and fuel resources may become unsustainable at the present rates of consumption. The energy, water, consumption and pollution nexus and its likely impact on climate change will remain a major focus of concern and attention in this century.

The priority everywhere remains the assurance of universal access to affordable, reliable and modern energy services. More people are moving out of poverty and are demanding and gaining access to energy and electricity. Several studies suggest that global energy demand will double by 2050 compared with 2000 levels (emerging economies will be responsible for 90% of growth in energy demand caused by rising populations and middle classes).

- **The following targets are recommended for 2025**:
  1. Attain higher energy efficiency in production and use in all sectors by 50% with a different energy mix.
  2. Integrate modern energy infrastructures including micro-grids into national systems.
  3. Increase the number of cities and human settlements which adopt and implement integrated policies and plans towards use of renewable energy, resource efficiency, mitigation and adaption to climate change, and resilience to disasters.
  4. It is emphasised that energy related activities offer an important opportunity for industrialisation through manufacture of energy/power plant equipment in OIC countries.

7.1 Energy Autarky:

The goal of energy autarky will be met through diversification of primary resource which, in turn, is governed by national domestic resources, policies, and programmes. This is impacted by volatility in global pricing and geo-politics or competition for resources. The move towards RE (renewable energy) will be sustained, although its share in the primary energy mix will still be over- shadowed by fossil fuels.

Most studies suggest that the share of fossil fuels is likely to remain around 75% of global energy mix in 2050. Since coal fired plants will continue in operation or will still be built [8].

It is imperative to move towards systems with high efficiency (48%-60%) based upon super critical and ultra-super critical plants (using high pressure / high temperature boilers) which also help reduce the carbon footprint considerably.

7.2 The Case for Renewable Energy:

The problem with RE (solar, wind) is that it does not offer 'base-load' supply, which is only available through fossil or nuclear fuels. The RE output is intrinsically variable and even

[8] Ref: Smil, *Energy Transitions* (2011); also EXXON: 2012; *The Outlook for Energy: A View to 2040. Also: The New Policies Scenario, NEA, 2015.*

intermittent, which is the biggest challenge for its integration with existing systems. Hydro-power too cannot always provide base-load in many OIC Countries, as it can be seasonal, with its primary function being water storage for agriculture. Bio-fuels can have negative impact on food crops, and reaching 2% of global share could require an area as large as France.

Overcoming such fluctuations and providing 'base-load' equivalence through improved storage systems, as well as upgrade of transmission / distribution systems is therefore crucial to allow shift in 'time' for wider acceptance of RE.

RE everywhere has another limitation in that special subsides and FITs (Feed-in-Tariffs) are required for its adoption. Since these cannot be available indefinitely, their adoption is stalling in the advanced countries.

The focus of scientific and technological research must therefore be to design large scale storage technologies, which offer / leverage multiple applications in regular grid based systems, such as covering peak demands and improved power quality and frequency regulation. Local micro-grids can help in reducing transmission needs. These requirements are already having major impact on the evolution of flexible two-way T&D (transmission and distribution) systems and grids of the 21st Century.

- **The goals and targets recommended for 2016-25 are :**

  i. Aim for a RE share of 10% in national energy mix of OIC Countries.

  ii. Introduce micro-grids and manage their integration into national systems

  iii. Enhance research for increasing solar cell efficiencies to reach commercially deployable conversion factors of 40% in research institutions.

  iv. Design and develop fuel cells with a target of 5 MW for 2 hours.

  v. Enhance intra-OIC and international cooperation to facilitate access to clean energy research and technologies such as carbon capture and storage.

7.3 The Case for Nuclear Power:

There is a revival of interest globally in nuclear power, drawing upon lessons learnt from the Fukushima disaster.

Several new power plants are in various phases of planning and execution in the OIC countries. Excellent opportunities exist for cooperation in both power and non-power applications of nuclear technology. Collaboration in peaceful applications of nuclear technology in power and non-power sectors will be encouraged consistent with respective international obligations of Member States and regulatory safety / security standards as enunciated by the IAEA (International Atomic Energy Agency).

COMSTECH will prepare, in collaboration with IAEA, and OIC countries with the relevant experience and expertise a training programme for engineers and technicians on nuclear power plant operations, safety, security and regulatory matters.

7.4 One Planet: Environment, Climate Change and Sustainability.

We have only one planet as our habitat for the foreseeable future and it is facing a crisis of unimaginable proportions. Climate change and global warming is anthropomorphic, i.e. caused by human activity, and can be controlled only by changing the patterns of human activity.

Scientists now believe that the negative impact of climate change may have been underestimated. It is therefore imperative to restore and maintain the natural ecosystems in order to meet the challenges caused by climate extremes though integrated approaches which cover identification, impact assessment, adaptation, and mitigation measures.

While climate change is a worldwide concern, it is of particular concern for OIC states lying in climate-sensitive regions. It has major negative impact on poverty, food security, and the burden of disease, which are already aggravated by degradation of land, water and the environment, especially the marine environment and fisheries therein. Another area of concern is the rapid global urbanisation, with some 70 percent of people living in cities.

Managing the projected social dislocation will require a high degree of cooperation among the OIC countries. Unfortunately, most OIC countries lack the necessary know-how and capacity to scientifically address these challenges and counter them through appropriate adaptation and mitigation measures.

It is recommended that a Climate Change Panel drawn from the OIC Standing Committees and experts from Member States be set up to prepare up a detailed plan of action including mitigation options. Its terms of reference would include:

i. Prepare a template of green technologies which encompass the human habitat.

ii. Reducing and managing urban, agricultural and industrial waste

iii. Policies for protecting and restoring ecosystems including mountains, forests, wetlands, rivers, aquifers and lakes.

iv. Promoting mechanisms for raising capacity for effective planning and management of climate change, and reducing the exposure and vulnerability of poor to climate-related extreme events. This entails detailed modelling and simulation, for which proposed High Performance Computing Centres (HPCCs) proposed earlier in sub-sections 4.1, 5.1, 6.1) would be critical.

OIC States must actively participate in implementing the recommendations of COP 21 .

SECTION III : Proposals for Multinational Big Science Programmes

The present trend in scientific research is for large joint programmes which encourage and leverage multidisciplinary frontier research in physics, mathematics, chemistry, biology, climate change, satellites, oceanography, earth sciences and technological innovation.

This can take the form of accelerators, small Tokamaks for plasma physics experiments, mapping the oceans and seas around the OIC country coastlines, small satellites for resource mapping or sending joint teams to Antarctica. Several countries can pool their human and financial resources for joint designing, implementation and operation of large programmes which can reduce financial burdens on individual states. This will also lead to better collaboration and collective capacity building which is the Vision of all OIC member countries.

COMSTECH is also in contact with several international agencies in order to initiate and collaborate in such programmes, in addition to experts available within OIC countries.

- **The following is recommended** :

1. *Space:* Muslims too could venture into space in the near future. For this we need to be worthy of such an enterprise by creating the proper mindset and a core group of scientists and engineers who have the necessary expertise and vision to do so. In addition, given the immense contributions of space science and technology and applications for socio-economic development, due attention should be accorded for enhancing natonal capacities in this field as well as regional cooperation at all levels. Space programmes are expensive, and barring a handful of countries, require multinational efforts to minimises costs and enhance outcomes.

   It is recommended to design and launch small satellites jointly by involving several member states. These will be used for remote sensing (as happened in Egypt for underground aquifers), or crop estimation and disaster management (as is being done in Pakistan), rescue at sea, and weather prediction. In addition, small satellites can be used for elegant experiments related to space plasma and ionized particles, micro-meteorites, shifting of the magnetic poles, validation of data communication, as well as biological experiments and materials validation under space conditions.

2. *Astronomy:* There are no reasonably sized, functional astronomical telescopes in Member States, whereas this is one area where Muslim scientists made seminal contributions in the past. Presently, ground-based telescopes with 2.4 - 3.0 m aperture and using adaptive mirrors and laser 'guide stars', can provide nearly the same resolution as the Hubble space telescope. *It is recommended* to establish at least three such observatories in different OIC regions.

3. *Accelerators and Synchrotron Light Sources:* Accelerators and synchrotron light sources permit multidisciplinary research at the frontiers of human knowledge in mathematics, particle physics, materials, chemistry, biology, and handling of extremely large data. A medium sized synchrotron light source will provide radiation interaction down to the extreme UV and X-rays, apart from providing excellent opportunities for technology and industrial development. *It is recommended* to complete the SESAME machine in Jordan as quickly as

possible and also initiate work on more synchrotron sources in Member countries.

4. *Mapping the Marine Environment of OIC States:* The oceans are a source of food, water, energy and raw materials, a medium for tourism, transport and commerce. Some 10 million square km of coastline needs to be mapped. Collaborative and cross-disciplinary research is the key to providing the knowledge and tools that we need to achieve ecosystem-based management and protection of valuable marine resources and services.

   The majority of member states are maritime states and are interconnected from the Atlantic through the Mediterranean via the Red Sea, the Arabian Sea, and Indian Ocean to the Pacific Ocean and share in common the waters and resources.

   Under the United Nations Convention on the Law of Sea (UNCLOS) of 1982, the maritime jurisdiction of OIC member states has been extended to about 10 million square kilometres of Exclusive Economic Zone (EEZ) where they have sovereign rights over the resources. Most of these oceanic areas represent some of the most productive marine regions of the world oceans, characterized by phenomena favourable for rich fisheries, minerals and oil and gas resources.

   It is recommended to initiate a major programme for reviewing and compiling bathymetric data of the marine environment under the jurisdiction of member states. The data and map products will provide information on the sea-bed substrate including rate of accumulation of recent sediments, the sea-floor geology, and structural configurations including faults at the appropriate scales, geological events and probabilities, and minerals. Information on coastal type and behaviour will be supplemented by information on coastal erosion or sedimentation processes. All interpretations and primary information will be owned by the project partners, supplemented with other information in the public domain.

   - At least four oceanographic survey vessels will be commissioned; these will be equipped for bathymetry; geology; geophysics, seabed habitats; chemistry; biology; physics; and human activities.

5. *Mapping and Preparing the Minerals Directory of OIC States:* Apart from oil and gas, the OIC region is blessed with large mineral deposits. Kazakhstan produces a third of the world’s uranium, while Afghanistan holds nearly half the global reserves of lithium in addition to other strategic minerals. The uncharted coastlines promise much more. All this needs to be mapped and disseminated, and a Minerals Directory prepared in collaboration with Natural Resources Authorities of OIC Countries.

6. *High Performance Computer Centres (HPCCs):* Modern research demands high performance computing. Such facilities are in demand by all the scientists and groups who were consulted by COMSTECH. This has already been highlighted earlier. Six HPCCs would gradually be set up in the major regions of OIC of Member States, and will be shared by scientists in academia as well as by industry.

7. *The Challenge of Climate Change:* While climate change is a worldwide concern, it is of particular concern for OIC countries lying in climate-sensitive regions. It has major negative impact on poverty, food security, and the burden of disease, which are already aggravated by degradation of land, water and the environment. Managing the projected social dislocation will require a high degree of cooperation among the OIC countries. Unfortunately, most OIC countries lack the necessary know-how and capacity to scientifically address these challenges and counter them through appropriate adaptation and mitigation measures.

   With OIC partners, COMSTECH will sponsor research in climate change, starting with one High Power Computation Centre (HPCC) at COMSTECH HQ in Islamabad. This facility will be available to OIC researchers and can also be used for designing new molecules and drugs.

8. *Communication and Industrial Equipment:* OIC Countries are major importers of communication equipment and other hardware, costing hundreds of billions of dollars. Over the *years*, considerable expertise and industrial base has been built up in design and development of such equipment. This infrastructure can be used for jointly developing a wide variety of equipment through 'groups' of industries specialising in one or more type / sub-type of equipment, which are located in different countries. Such a consortium will invariably develop entirely new SME supply chains.

9. *Equipment for Energy and Power*: The world is moving towards electrification of national economies and the estimated cost of upgrade of existing infrastructure or building new plants runs into several trillion US dollars. Expertise for building power plants, including plants running on fossil fuels or nuclear fuel already exists in several member states.

   COMSTECH will prepare a study of such expertise and facilities with partners in OIC Institutions and Member States, with a view to proposing a consortium which can design and build major modules of such plants, such as boilers, generators, turbines and control rooms.

10. *Joint Manufacture of Teaching Aids /Laboratory Equipment:* COMSTECH will explore with partner organisations drawn from the OIC Countries the possibility of their design and manufacture for use from the school level to the university.

11. *Managing Rapid Urbanisation and Growth of Mega Cities*: Because of steady migration of people from rural to urban areas, cities are now evolving into centres of economic activity and power because of the clustering of physical and electronic infrastructure and the availability of skills and services. The urban sprawl calls for active planning to enable such cities to grow in an optimal manner in line with goals of a sustainable habitat. COMSTECH will initiate studies with partner organisations to prepare for its better management.

12. *Harmonising Trade Laws, Industrial Standards and IP Laws* : As trade develops among OIC States, it will be necessary to harmonise legal and regulatory framework to facilitate this process. Intellectual Property Laws will be a priority.

While the total estimated funding requirements is already available with COMSTECH, It will be firmed up after endorsement of the recommendations by Member States at the COMSTECH General Assembly for approval at the OIC Summit on Science and Technology. Thereafter a detailed Action Plan will be prepared by COMSTECH in association with Member States, OIC Organisations and Institutions, and experts.

Further details of costs, timelines, and national shares are given in Section VI.

SECTION IV : Enhancing Cooperation Among OIC Countries

There is little scientific cooperation among member states. A major factor is the lack of awareness among academics and scientists of the strengths of institutions or the expertise available in different countries, in addition to the heterogeneous nature of educational and scientific quality levels across the OIC member states. Further, there is no coherent mobility programme with its associated funding.

COMSTECH has conducted a series of advanced training workshops at the frontiers of science and technology for several years, but meaningful collaboration remained restricted only to a few individuals. COMSTECH also prepared a data base of active scientists in member states. This will be updated.

All Member States and OIC organisations need to move into a more pro-active role for identifying the needs of Member States and building up appropriate data bases for implementation of focussed programmes.

1. Centres of Excellence: 'Mother / Focal Institutes'

The consultation process has identified several strong Centres of Excellence in many OIC Countries in education and research. These cover physical and social sciences, high technology, space systems, atomic and nuclear physics, oceanography, earth sciences, simulation and modelling, lasers and optoelectronics, as well as energy and power plants. Existing groups and centres will be improved, and new centres will be gradually developed to enhance complementarities across the Member States.

All these groups and Centres are expected to emerge as 'Mother Institutes' which will be at the heart of collaborative efforts in OIC Member States.

- **The key themes and actions are:**

  i. Compliment one another's knowledge and technology base, and hence build collective competence and 'transfer' of knowledge.

  ii. Build smaller linkages first, which may be bilateral or trilateral initially, growing into regional groupings over the next ten years.

  iii. Acquire and maintain data pertaining to human and physical infrastructure relating to S&T and prepare a common in order to facilitate exchange of students across countries.

  iv. Initiate focused "mobility programs" for students, faculty and researchers within OIC, and with non-OIC countries.

  v. Recommend 'seed' grants for research programs built around well qualified scientists and associated infrastructure.

In addition, economic spillovers from S&T will be facilitated by encouraging the development of technology driven SMEs (small and medium enterprises) through S&T parks and appropriate financing mechanisms.

vi. **A major mobility exchange programme** is proposed for scientists, researchers and students from the OIC countries. *The OIC Exchange Programme may be named as* ***the Al Haytham Programme,*** after the Muslim scientist Ibn Al Haytham, regarded as the father of modern optics. UNESCO has named 2015 as the International Year of Light, which year is also the 1000th anniversary of the remarkable seven volume treatise on optics - Kitab al-Manazir - written by Al Haytham. His methodology of investigation, in particular using experiment to verify theory, shows certain similarities to what later became known as the modern scientific method

vii. **Finally, an Exhibition is planned during the Summit period in 2017.** This will highlight research innovation / products emerging in technology as well as enhancement of cooperation in educational and scientific / technological infrastructure in OIC member states. This will include a poster exhibition to underscore the activities of various OIC S&T organisations in the domain of STI.

To supplement these activities, COMSTECH will update its *'Directory of Active Scientists, Technologists / Engineers'* in member states and their recent scientific publications. The earlier Directory is a massive publication (22 volumes, over 16,000 pages) based upon internationally abstracted information from thousands of scientific journals arranged according to fields and sub – fields. It is widely acclaimed and has been very helpful in creating joint programs and collaborations among the OIC scientific community.

At the OIC organisational level, it will be necessary to Identify and devise collaboration mechanisms which will not be handicapped by multiple OIC agencies and the resultant lack of cohesion.

COMSTECH will therefore work in close collaboration with Member States and the OIC Secretariat, OIC organs, subsidiaries and affiliates, and the IDB to identify and facilitate the implementation mechanisms, through peer groups made up of leading scientists, technologists, and educationists from Member States. In doing so, COMSTECH will also draw upon recommendations of Member States and relevant sectoral Ministerial meetings of OIC.

A draft implementation strategy and structure is given in Section V.

SECTION V: Implementation and Funding Requirements

No programme would be sustainable without adequate funding and its effective monitoring. The goals and work plans listed in this Document are extensive and even ambitious, but they are desirable and implementable if the proper framework for funding and implementation are in place. The goals cover basic societal needs for education, skill development and employability of citizens, and the entire spectrum of higher education, research and innovation, as well as 'big' science programmes. The focus has been on implementable activities which draw on the combined strengths and expertise available in member states.

1. **Estimated Expenditures:** While the total expenditure estimated over the next ten years is available, its final amount will be determined later, after the endorsement of the COMSTECH Plan by the General Assembly of COMSTECH. Budget support over 10 years from non-national sources will be small, as most of it will be borne by the host country/ beneficiary. To put this in perspective, Pakistan invested US$ 7 billion in higher education and research alone in the last 10 years.

   The cost breakdown of activities is as follows: (Some details in Table 1 below)

   i. **Infrastructure and Research: US$1090 million.** Member countries are expected to contribute 50% of costs as matching grants.

   ii. **'Big' Science Multi-National Initiatives: US$ 835 million.** The entire cost will be borne by the partner countries, barring a few exceptional cases. External funding will also be available from a common funding pool.

   iii. **Venture Capital and Soft Loans : US$ 160 million.** This is recommended for entrepreneurship and new high technology start-ups for those innovative ideas that possess good business potential. This will enable research activities to grow into technology ventures, or for existing technology based SMEs which have potential, to grow into international 'Brands'. This would operate on strict principles of venture funding, which will help it to become self-sustainable and thus support further entrepreneurship**.** The beneficiary country will provide 50% matching grants.

   The Venture Capital Fund and Soft Loans Facility will enable efficient use of S&T for economic development. Several sectors are promising, but some sectors have considerable immediate business potential :

   i. Design and Manufacture of Bio-Medical Equipment.

   ii. Design and Manufacture of Laboratory / Teaching /Test Equipment for schools, technical colleges and universities.

   iii. Joint Consortiums for Communication and Industrial Equipment.

   iv. Joint Consortiums for Equipment used in Power Plants.

It may please be noted that these expenditures would be in addition to national funding programmes. If desired , additional sources of funding will be explored.

2. **Table 1: Costs and Timelines for Various Programmes, 2016-25**

#	Activity	Time, Years	Total	Ann. Avg.
			US$ (m)	
1.	**Infrastructure and Research**			
a.	Infrastructure and HR Development (universities and Research Institutions, Including Higher Studies, etc)	10	450	45
b.	Research Grants in various Disciplines	10	500	50
c.	Gene Banks for Preservation of Plant Diversity	10	50	5
d.	Mobility of Scientists as Part of S&T Cooperation	10	40	4
e.	Training of Technicians in Research Labs and Industry	10	20	2
f.	Storage Systems for Renewable Energy	10	20	2
g.	Development of Improved Laboratory Equipment / Aids	5	10	2
	➢ [1] **Total Research Fund, US$(m)**		**1090**	**110**
2.	**Multinational Programmes**.	3-10 years		
a.	Resource Mapping Satellite, (one)	5	370	60
b.	Accelerator / Synchrotron Light Source, (one)	10	200	20
c.	Astronomical Telescopes, (three)	7	125	18
d.	Joint Mapping of Marine Environment	5	50	10
e.	OIC Minerals Directory	5	10	2
f.	High Performance Computation Centres (six)	3	15	5
g.	Modelling of Climate Change	10	20	2
h.	Consortium for Communication and Industrial Eqpt.	4	10	2.5
i	Consortium for Equipment for Energy and Power	4	10	2.5
j.	Rapid Urbanisation and Planning of Mega Cities	5	15	3
k.	Harmonise Regulations for Cyber Security	5	10	2
l.	Harmonising Trade Laws /Industrial Standards / IP Laws	5	5	1
	➢ [2] **Total for Joint Multinational Programmes, US$ (m)**		**835**	**128**
3.	**Venture Fund for Technology Start-Ups**	10	100	10
4.	**Soft Loans for Existing Technology Based Businesses**	10	60	16
	Total for Economic & Industrial Applications of S&T, US$(m)		**160**	**16**
	GRAND TOTAL, US$ 2085 m (see Note below)		**Yearly Avg. : 254m (see Note)**	

Note : [1] 50 % contributed by beneficiary country. [2] Partner countries will provide 50%. More details to be finalised, when partnerships are established.

3. ACTION PLAN: Project Identification, Implementation and Monitoring

An Action Plan is being prepared under the aegis of COMSTECH in consultation with Member States and relevant OIC entities and experts. This will clearly spell out roles and responsibilities for implementation of the activities, with a view to ensuring harmonization and synergy and avoiding duplication of efforts.

It will include:

a. Detailed cost estimates, timelines and Key Performance Indicators (KPIs) through specialised sector Groups.

b. Process Implementation through a number of Thematic Committees, each of which is steered by a Working Group drawn from Member States.

c. The Member States will be at the centre of the entire discourse. They are welcome to take part in joint activities. In all cases, they will help manage the programmes through their nominees on the Committees.

The typical Structure for Implementation may be as follows:

Members	**STEERING COMMITTEE, Chaired by COMSTECH**					
Core Members	**IAS**	**ISESCO**	**COMCEC**	**COMIAC**	**OIC Sectt.**	**IDB**
Regional Advisors	**Five Leading Scientists (One each from W. Africa, MENA, C. Asia, S. Asia, S.E Asia)**					

THEMATIC GROUPS, with Experts from Member States / OIC Organs

Basic and Applied Sciences	ICT& Cyber-security	Food, Water, and Agriculture	High Performance Computer Centres (HPCCs)	Technical & Vocational Education	Harmonisation of Trade Laws & Industrial Standards
Groups for Big Science Projects				Intra-OIC Accreditation of Universities and Mobility of Scientists	Venture Capital & Soft Loans for Hi-Tech start-ups
• Space • Oceanography • Earth Sciences	• Climate Change • Synchrotrons • Astronomy		**Joint Manufacture:** • Power Plants • ICT • Lab. Equipment		

Conclusions: The COMSTECH Ten Year Plan of Action in Science and Technology for OIC Member States has been drawn up after extensive consultations with scientists and technologists from twenty countries.

Apart from emphasising the current excitement in science and technology everywhere, it is an attempt at sensitising governments, policy makers, and the public in OIC Member States to partake wholeheartedly in the great game of the 21st Century – science and technology.

The pursuit of knowledge and the new frontiers which follow, will witness an ever increasing impact on all of humanity in the 21st century. Its influence on the way we live and work and communicate with one another is enormous and a new relationship is emerging between science and society, whose morphology is as yet unclear.

Let us prove worthy of this great enterprise.

The Document attempts to present a holistic view of emerging science and technology and its social and economic spinoffs. It examines the multidisciplinary nature of modern science as well as some big science programmes, which can be jointly undertaken by several countries working together and sharing the cost thereof.

The Document examines mechanisms for building collective competence in a wide array of activities ranging from water, food and agriculture to energy to the basic sciences including international linkages with the best in the world.

The Document also acknowledges that science is disruptive, and flourishes in an environment of irreverence. Science and technology offer the tools for making societal changes as well as managing them. However, some basic ingredients must be present before good science can take root and flourish in an OIC Member State.

Estimated Costs for implementing the various programmes which will enhance the capabilities of Member States to higher levels. The total cost is about US$ 2085 million spread over 3-10 years, depending upon the programme.

The funds will be managed and operated by a Steering Committee to be drawn from OIC Standing Committees, Organisations, and experts from Member States. The various Thematic Groups will report to this Steering Committee.

The large multinational initiatives can be undertaken jointly by several countries, which will help in reducing costs of the partner nations apart from fostering collaboration within OIC and with international partners. It is not expected to be a substitute for normal national funding and budgets.

It will be the prerogative of the individual Member States to decide to take part or not in multinational programmes

Annexure 1: Key Themes / Guidelines for Consultation with Scientists and Experts from OIC Countries.

1. S&T for Development

a. Playing 'catch-up'

b. Making people employable

c. Enhancing productivity in manufacturing sector / SMEs

2. Building a Science Culture and the Thinking Mind

3. R&D in Emerging Sciences

a. **Basic sciences** (physics, mathematics, biology, chemical sciences, engineering, energy, agriculture, electronics, photonics).

b. **Big science** (accelerators, fusion, astronomy, climate change, marine biology, earth sciences, oceanography, etc).

4. Managing Meta-Data; ICT and Cyber Security; Future Data Availability

5. Capacity Building

a. **Strengthening** linkages among institutions of member states.
   - Mobility of scientists and students among Institutions.

b. **Improving** curricula and teaching methodologies.

c. **Introducing** a more rigorous monitoring and evaluation process for S&T projects / awards / scholarships.

d. **Bridging** the communication gap between scientists and society.
   - Role of the media in popularisation of S&T in OIC countries

6. Energy, Water, and Food Security

a. Opportunities and threats

b. Preserving biodiversity and crop genetics

7. Health and MDGs / SDGs

Annexure 2: Statistics on Education, Science, and Health in OIC Countries

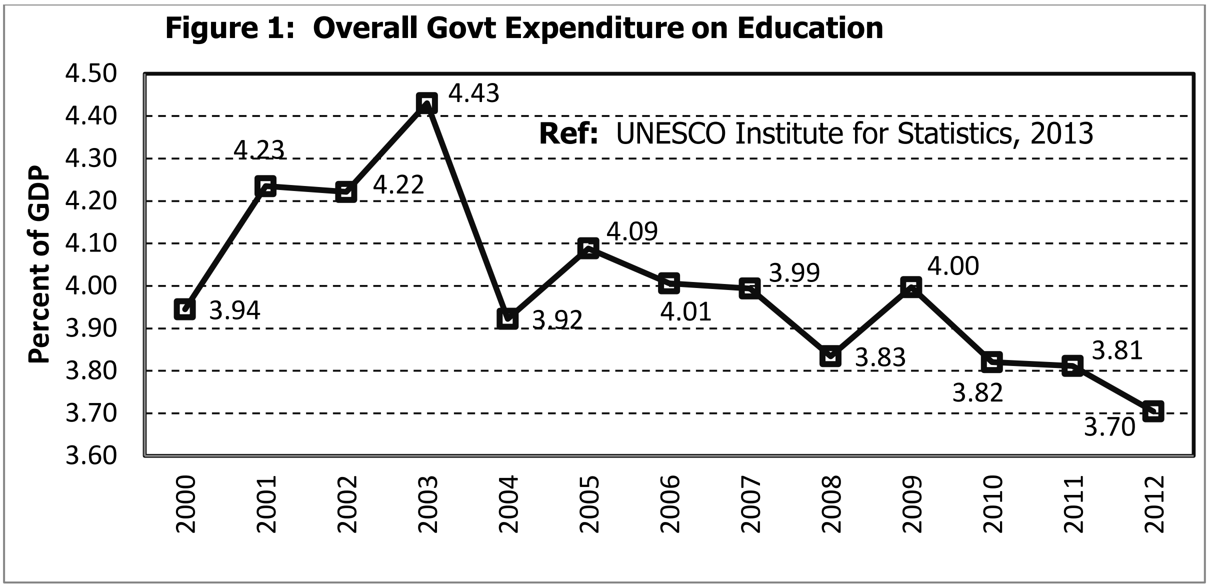
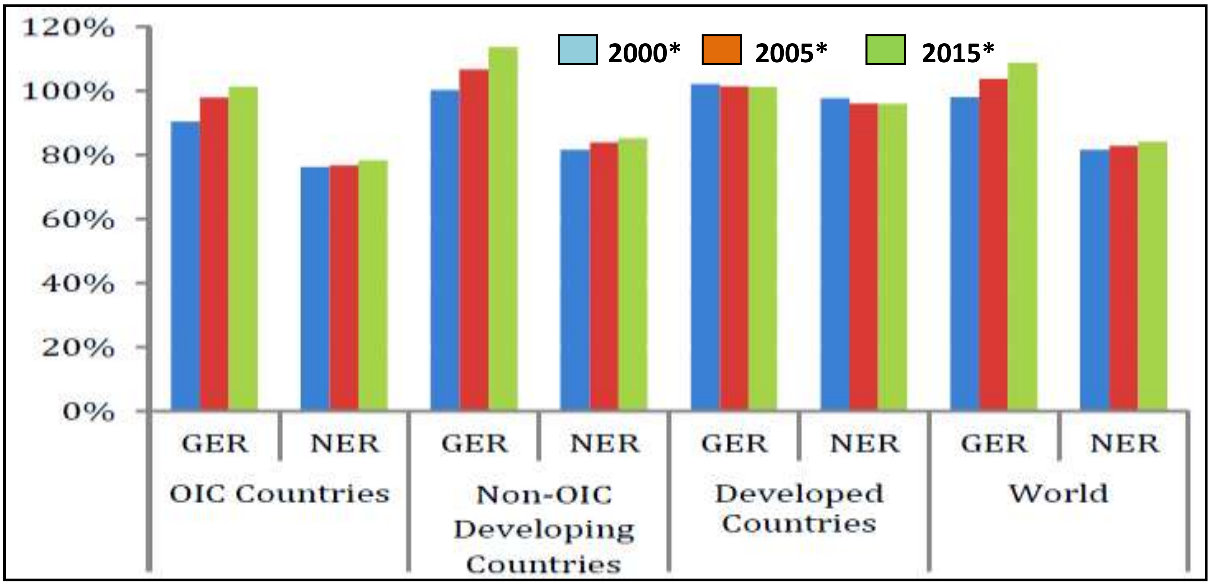


Figure 2: Gross Enrolment Rates (GER) and Net Enrolment Rates(NER) in OIC



Ref: SESRIC; Education And Scientific Development in OIC Countries, 2014

Also: UNESCO; World Bank WDI, World Bank Education Statistics. * Or latest year

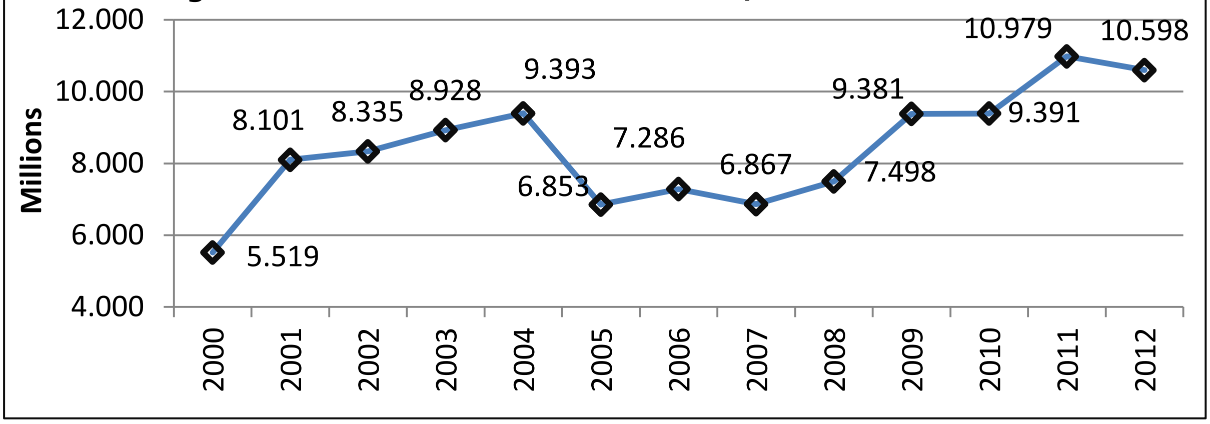


Figure 3: OIC Enrolments in Technical / Vocational Education

Ref: SESRIC; Education And Scientific Development in OIC Countries, 2014
UNESCO; World Bank WDI, World Bank Education Statistics. * Or latest year

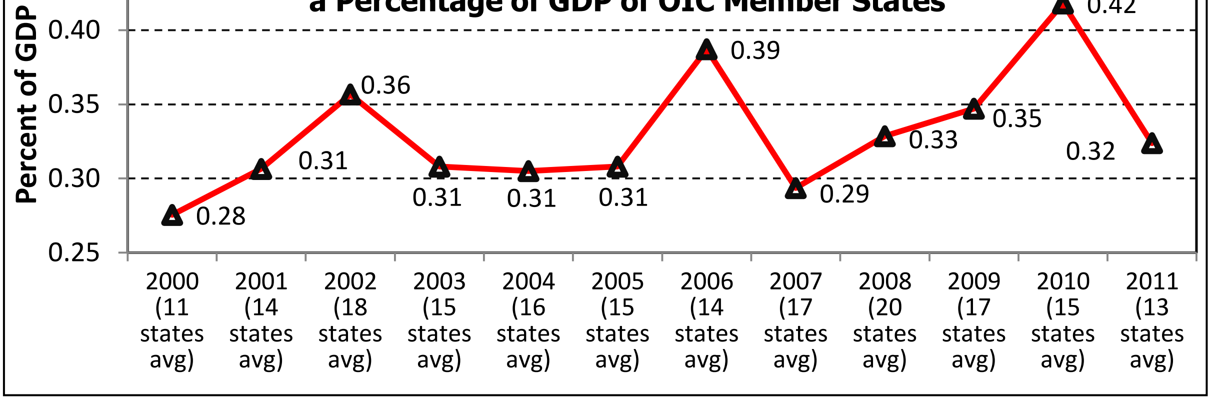


Figure 4: Gross Domestic Expenditure on R&D (GERD) as a Percentage of GDP of OIC Member States

Ref: UNESCO Institute for Statistics: Yearly Average, 2011, or latest available

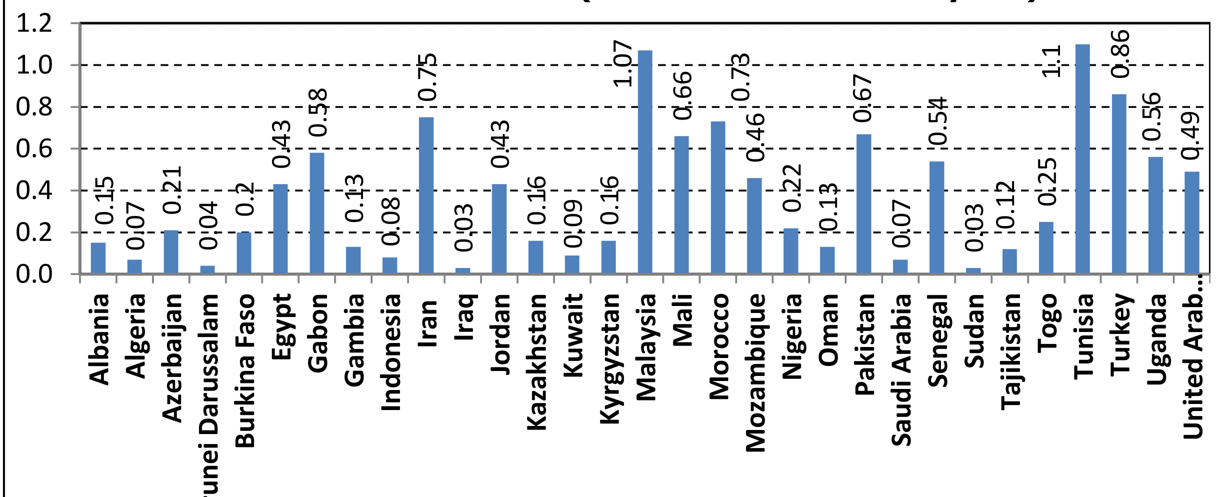
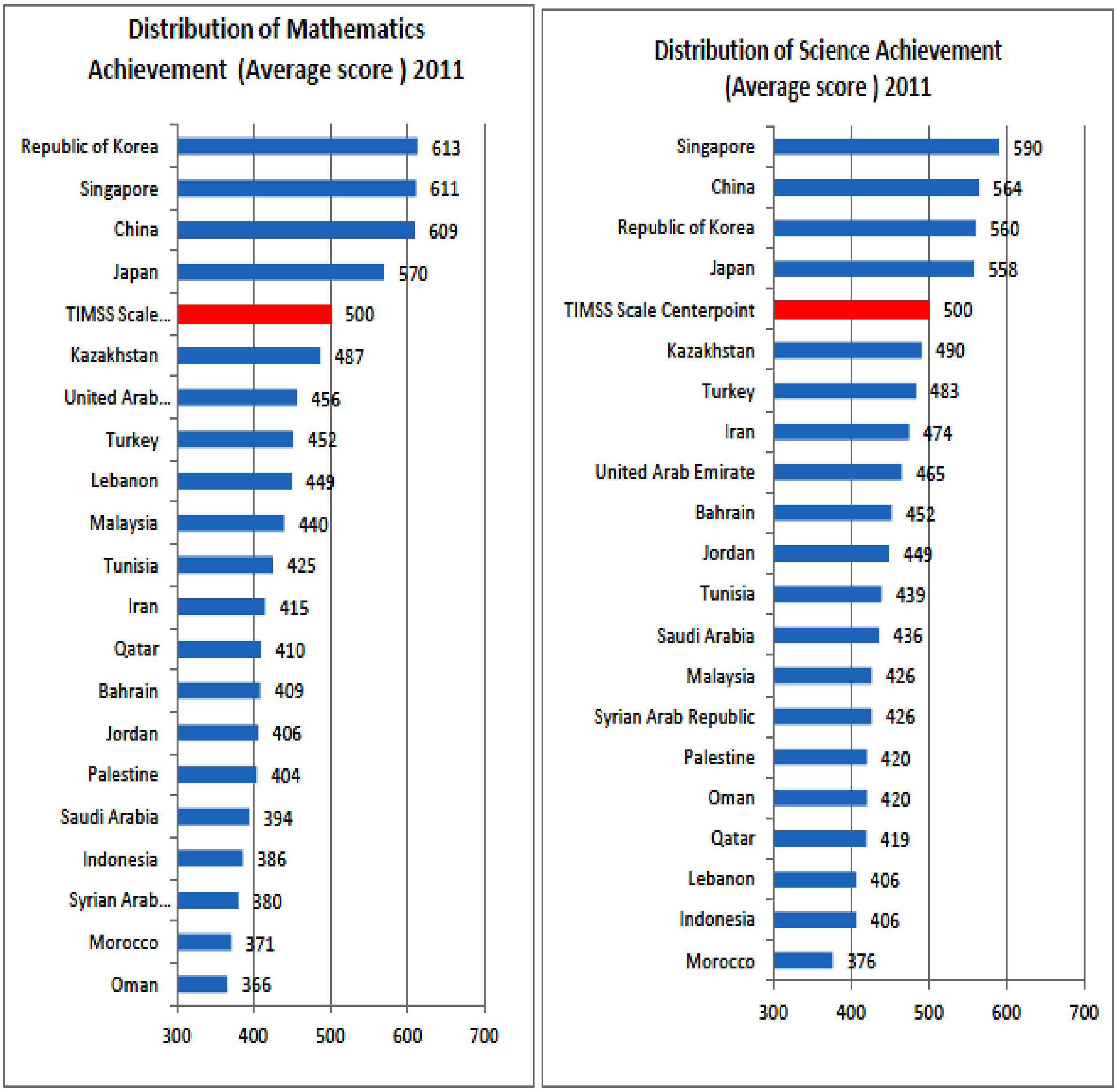


Figure 5: Gross Domestic Expenditure on R&D (GERD), as % of GDP of 31 OIC Countries (2011 or latest available years)

Source: UNESCO Institute for Statistics

Figure 6: Non-Competitive State of Secondary Education in OIC Countries



Source: Trends in International Mathematics and Science Study – TIMSS 2011, TIMSS & PIRLS International Study Center, the Lynch School of Education, Boston, Mass.

Lower enrolments at the secondary level reduces the knowledge and skills capital of OIC member states and makes them non-competitive.

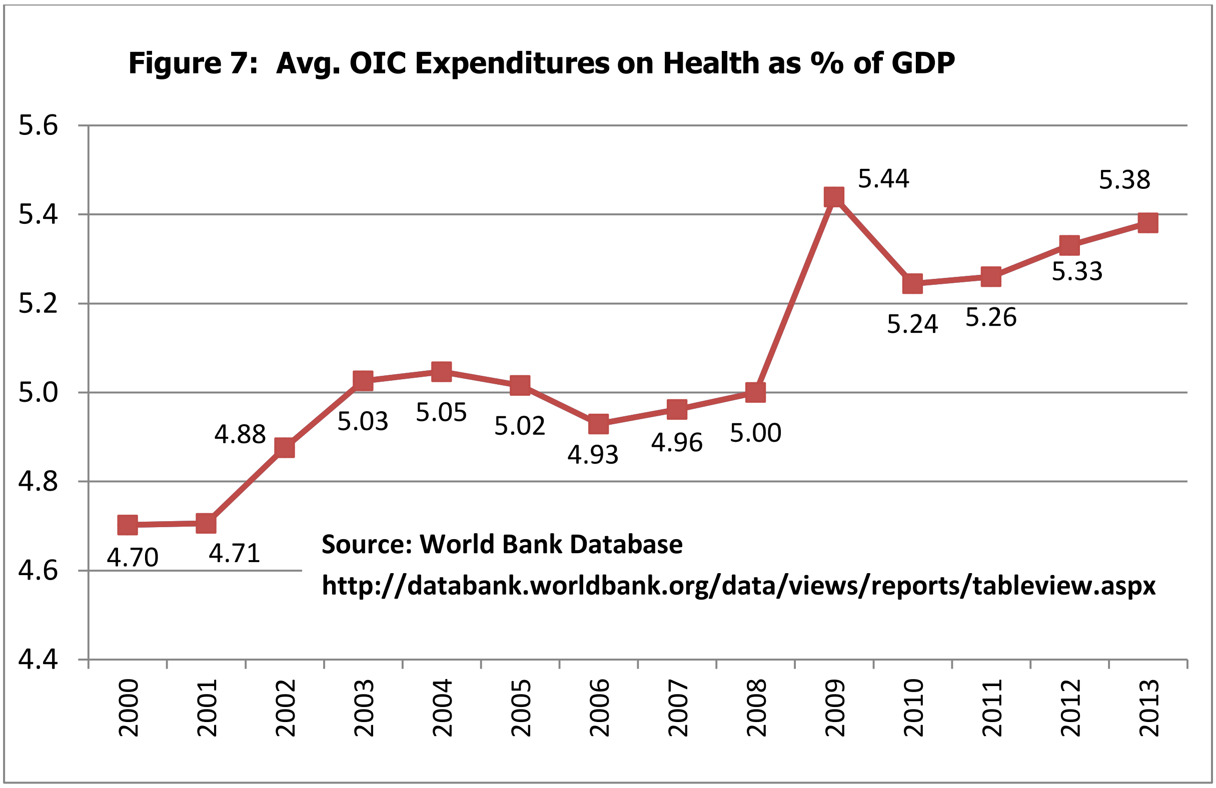


Table 1: Number of doctors / 10,000 population in the OIC countries.

The top 10 countries are:

Country	Doctors/10,000
Qatar	44
Turkmenistan	42
Kazakhstan	37
Azerbaijan	36
Lebanon	31
Uzbekistan	26
Kirghizstan	23
Jordan	23
UAE	21
Tajikistan	20

9 countries have between 10-20 doctors / 10,000
5 countries have between 5-10 doctors / 10,000
6 countries have between 2-5 doctors / 10,000
22 countries have with less than 2 doctors / 10,000

Ref: World Bank. Data for 2012 or earliest available

Note: The minimum threshold under the MDGs is 23 doctors, nurses and midwives/10,000 population (WHO, 2011)