# National Innovation System and the Need for an Upgradation Policy for Innovative and R&D Capabilities in Pakistan

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**Abstract**

*As depicted in the ITC pyramid and world technological status pyramid, Pakistan's indigenous technological capability (ITC) is very low. This is mainly due to the fact, that as in most developing countries, Pakistan has not yet developed an effective national innovation system to facilitate the development of its innovative and R& D capabilities. This paper explores the need to build Pakistan's, innovative and R&D capabilities, and consequently establishes as one of its findings, the need for policy intervention to develop and strengthen the national innovation system, in order to facilitate the innovation capability building process.*

***Keywords:*** *Capability, indigenous, innovation, Pakistan, research, technological.*

## Introduction

National innovation systems (NIS) play a crucial role in countries' efforts to catch up with technological advances (UNCTAD, 2005). (A well functioning national innovation system includes not only institutions and industry related to infrastructure, education, training and R&D activities, but also government legislations, standard setting institutions, industry structure and aspects facilitating international technology transfer and its absorption as well as the interaction among all these institutions.) Different educational institutions and systems, legislation, frameworks for technological activities and policies have a significant impact on a country's technological performances and in turn influence their economic performance.

However, national innovation systems in developing countries such as Pakistan are uncoordinated and fragmented, and thus constitute a major problem in building the country's indigenous technological capabilities (ITC).

Some of the common problems of the national innovation system in many developing countries include: (UNCTAD, 2005)

- A lack of networks of S&T institutions such as universities, research institutes, standards institutions;
- Isolation of these institutions from the productive sectors of the economy;
- Inadequate level of coordination between the main areas of public policy – fiscal and monetary, foreign investment, intellectual property, competition, trade, agricultural and industrial development, environment, health, etc. – that may be interrelated with investment in S&T development;
- Insufficient coordination between S&T policies at the national, regional and community levels;
- Lack of consultation with, and participation of all main actors – government agencies, business, academia, S&T institutions, consumers, labour and civic groups – in the formulation and implementation of S&T and innovation policies.

The following indicators are used to depict the status of innovation and R&D capabilities of a country (either strongly or poorly), and also make up the national innovation system of the country:

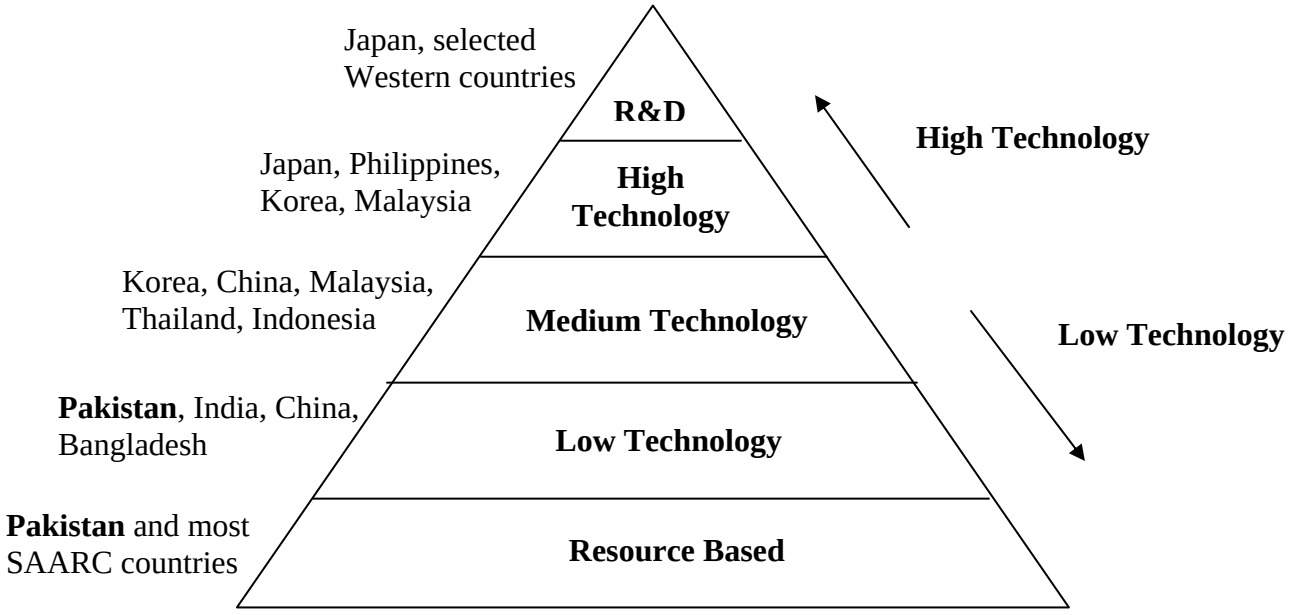
1. Research and Development (R&D) expenditure
2. Patent statistics
3. Research papers/journals
4. R&D Personnel
5. Areas of focus of R&D
6. Technical and tertiary education

Pakistan's R&D capabilities and the status of its national innovation system are indicated in the following data.

**R&D Expenditure as a Percentage of GDP**

The bar chart provided in Appendix 1 shows Pakistan's status in terms of its R&D expenditure as a percentage of its GDP, and indicates that Pakistan is lagging far behind other developing and developed countries in terms of this indicator. This measure is one of the most widely used indicators of an economy's commitment to growth in scientific knowledge and technological development; this therefore shows that Pakistan has a very limited R&D base, and subsequently *a low level of innovative capabilities* in comparison to other countries. This fact is further highlighted in the following diagram Figure 1 (Government of Pakistan, 2005):

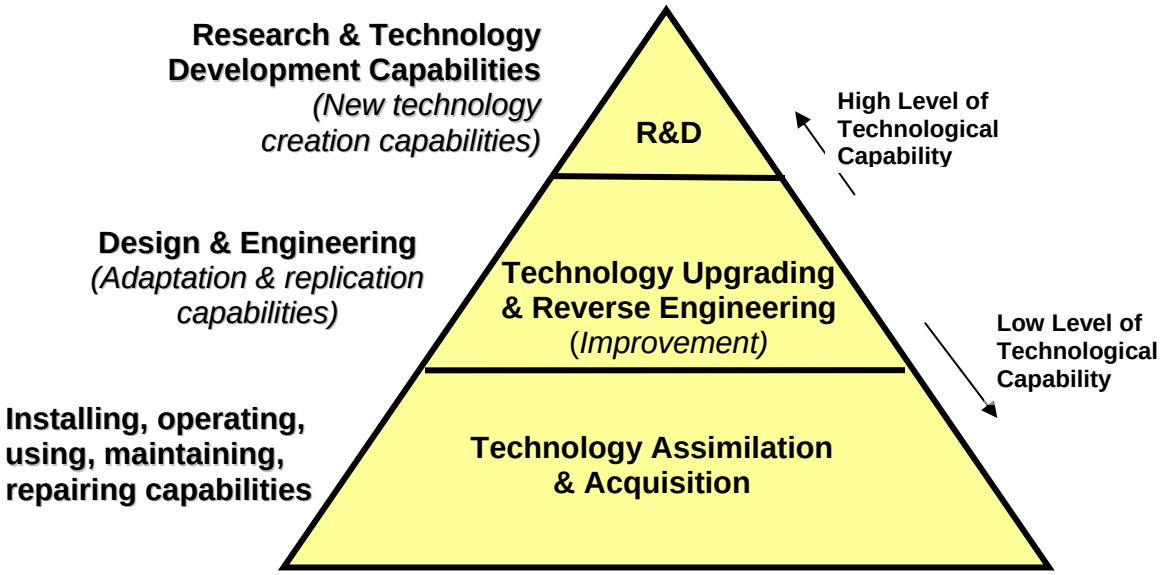
**Figure 1: World Technological Status Pyramid**




In order for Pakistan to move towards the apex of this pyramid towards R&D and innovation, it is necessary for it to develop its indigenous technological capabilities (ITC)

in this regard. This is only possible if Pakistan develops the capabilities to move towards the apex of the following ITC pyramid, as in *Figure 2* (Intarakamnerd, Chairatana, Tangchitpiboon, 1992):

**Figure 2: Indigenous Technological Capability Pyramid**




In order for Pakistan to reach the apex of both its ITC and technological status pyramids (Figure 1) (towards R&D), it is very much necessary for it to develop its innovative capabilities in this regard. However, given the market imperfections that exist, such a shift in paradigm is not possible without government interventions for technology deepening regarding innovation.

Thus, the development of *ITC for innovation* at both the national and firm level necessitates that a workable *policy framework* be in place. Development of R&D and innovation capabilities would also enable Pakistan to become a producer of certain cutting-edge technologies in key areas. Moreover, it is important to note that such interventions for research and innovation would also directly contribute towards the strengthening of a *national innovation system.*

**Patent Statistics**

Patent statistics can be used as measures of the *innovative output* of any country's S&T system. The table in *Appendix 2* indicates that *Pakistan was only granted a total of 350 patents in 2001, out of which only 12 were granted to Pakistani nationals.* This is in direct contrast to other developing countries such as Korea, China and India.

Moreover, Pakistan's ratio of foreign to local patents granted shows that *the number of patents granted to foreign residents in Pakistan was 28 times higher than the number of patents granted to Pakistani nationals.* In Iran and Korea's case, on the other hand, the numbers of patents granted to nationals were significantly higher than foreign nationals/companies. This indicates a stronger level of advanced innovation and R&D in these countries, and a lower level of R&D in Pakistan.

This low level of patents in Pakistan thus indicates that there are very limited levels of R&D taking place in Pakistan due to a lack of development of its innovative capabilities; this therefore implies that Pakistan is experiencing a lack of development of its ITC at the national level as well. It is therefore very much necessary for Pakistan to develop its ITC in this regard.

However, given the substantial number of externalities and market failures which may crop up, it is evident that the development of innovative capabilities at the firm and national level cannot occur under market forces alone, and thus require instead an effective form of state intervention to guide this development process.

**Scientific and Technical Journals**

The number of scientific and technical journals per million inhabitants may also be used as an indicator of Pakistan's technological capabilities regarding R&D and innovation. The graph in *Appendix 3* shows Pakistan's performance in this area. This graph highlights the lag that Pakistan suffers in the number of scientific and technical journals with respect to other countries in the region. This again indicates that Pakistan has not yet developed the upper-tier research and innovation based capabilities of both its ITC and technological status pyramids. A policy framework is thus required in this regard, in order to build such capabilities at the firm and at the national level, in the context of a **national innovation system**.

**R&D Personnel**

The bar chart provided in *Appendix 4* shows the increase in the number of PhD scientists involved in S&T activities in Pakistan from 1992 to 2003. Although the number of PhD scientists involved in science and technology has risen since 1992, *in 2003 there were still only 2860 PhDs involved in S&T activities in Pakistan.* This low number of scientists indicates that Pakistan lacks innovation and research capabilities. Interventions are thus required to build its indigenous technological capabilities in this regard, as per the ITC pyramid. The development of such innovation and R&D capabilities would also work towards the strengthening of a *national innovation system*, and this would subsequently enable Pakistan to become an *innovator*, rather than remain an *imitator* of technology in key sectors.

**Current Areas of Focus of R&D in Pakistan**

The bar chart in *Appendix 5* shows that the majority of R&D institutions in Pakistan are in *agriculture and health*, and only 16 are engaged in R&D in *engineering* (Naim, 2007). This trend of a greater emphasis on agriculture related R&D is further supported by the pie-chart provided in *Appendix 6.*

Again, the majority of scientists working in R&D organizations are engaged in research on agricultural sciences. Only 12.58% of the total number of scientists involved in R&D was involved in research in engineering (PCST, 2005).There is thus a critical need to shift the emphasis of innovation and R&D to areas other than agriculture, such as engineering. This would also help Pakistan gradually move away from resource-based and low-tech areas and instead towards medium and high-tech areas, and enable Pakistan to move up the technological status pyramid.

However, such a structural shift is not possible until Pakistan has developed its innovative capabilities and thus its ITC levels, both at the firm and at the national levels, along the lines of a directed *policy framework* for the development of technology, to enable and guide this entire process. Moreover, such a shift in emphasis towards high-tech and R&D based areas would also implicitly help to develop and strengthen a national system of innovation in Pakistan.

**Technical & Tertiary Education**

Human resources, particularly scientists and engineers, are one of the most important components of technological development. Without such skills, it is not possible to achieve good manufacturing capabilities, to produce significant innovations to undertake R&D, and so on. Hence, technical and tertiary education levels can be used as effective measures of Pakistan's innovative and R&D capabilities. The following data indicates Pakistan's status in this regard:

- Although technical education is currently being imparted by *57 technical colleges and over 700 vocational technical institutions* in Pakistan; currently, *less than one percent of Pakistanis* in the age cohort of 15-23 years takes up *vocational and technical education* after leaving school, compared to *70 percent in Germany*. Moreover, direct enrolment in technical and vocational education in Pakistan is 105,000, with another 115,000 engaged in tertiary level diploma and certificate programmes.

- Furthermore, on the World Economic *Forum's index of availability of scientists and engineers, Pakistan's rank was 61 out of 93 countries in 2005 (*Government of Pakistan, 2006).

This data thus indicates that Pakistan's level of enrolment in technical institutions is extremely low, especially in comparison to Germany's enrolment levels. Moreover, Pakistan's availability of scientists and engineers is also low; this data thus suggests that there is a need to develop the level of innovation, research and technical human capabilities in Pakistan. This need is further highlighted by the bar chart on *Pakistan's tertiary enrolment levels as provided in Appendix 7.*

Although the number of students enrolled at the bachelor's and master's levels have increased since 2001, the overall number of students still remains low. Furthermore, the number of students enrolled in MPhil and PhD programmes is even lower. Again, this indicates a lack of innovative capabilities in Pakistan, and thereby low levels of ITC in

this area. Thus, there is a need to develop such capabilities in Pakistan, in order for it to move away from imitation and towards innovation instead. However, the development of such capabilities will not take place on its own; domestic efforts at capacity-building are thus imperative, in the form of a consistent and concerted approach.

*Policy intervention* is therefore necessary to direct the development of Pakistan's indigenous technological capabilities and subsequently to strengthen the national innovation system in this regard.

**Supportive Technology Climate**

It is important to realize that this entire exercise of developing innovation and R&D capabilities to bring about a shift towards a national innovation system would not be possible until *a supportive technology climate* is in place. *Technology climate* refers to *the national setting within which technology based activities are carried out (UNESCAP, 1989).*

Moreover, differences in technology climates can cause similar transformation facilities or production units within two different countries to produce different results. Thus, a transformation facility is likely to produce better results in a *supportive* technology climate than in a *less supportive* one. Furthermore, it should also be noted that a supportive technology climate is also necessary in order to *make the most effective use of ITC.*

Without a supportive technology climate in place, it would neither be possible for Pakistan to develop its ITC capabilities as per its ITC pyramid, nor for it to bring about a paradigm shift towards high-tech and R&D areas. The development of a supportive technology climate is thus very much necessary in order to facilitate movement up to the apex in Pakistan's ITC and world technological status pyramids. Moreover, a supportive technology climate is imperative for the development of skills from low levels of sophistication in skills (operating capabilities) towards high levels of sophistication (design and R&D capabilities).

Hence, none of these interventions to move Pakistan from imitation to innovation will be effective without a supportive technology climate in place to facilitate this entire process. *Policy directions* are thus required in this regard, in order to *create a fostering and supportive technology climate.*

**Conclusions**

This paper explored the need for Pakistan to develop its *innovative and R&D capabilities.* Empirical evidence on innovation and R&D indicators substantiated the claim that Pakistan has not yet developed these advanced capabilities. In turn, these indicators also showed that Pakistan needs to develop a *national innovation system* in order to facilitate this innovative capability building process. Moreover, the need for a *supportive and fostering technology climate* to act as an enabling environment for this entire process was also emphasized.

Development of these R&D capabilities and thereby a national innovation system (under a supportive technology climate) would thereby enable Pakistan to shift its focus from

imitation towards innovation, and subsequently move up its ITC and technology status pyramids, towards a specialization in state-of-the-art technologies in certain key sectors. This would therefore enable Pakistan to make the transition from a national technology system towards a national innovation system.

However, such technology capability building cannot be left to market forces alone and instead requires government intervention in the form of a policy framework to channel the development of these capabilities in the context of a national innovation system.

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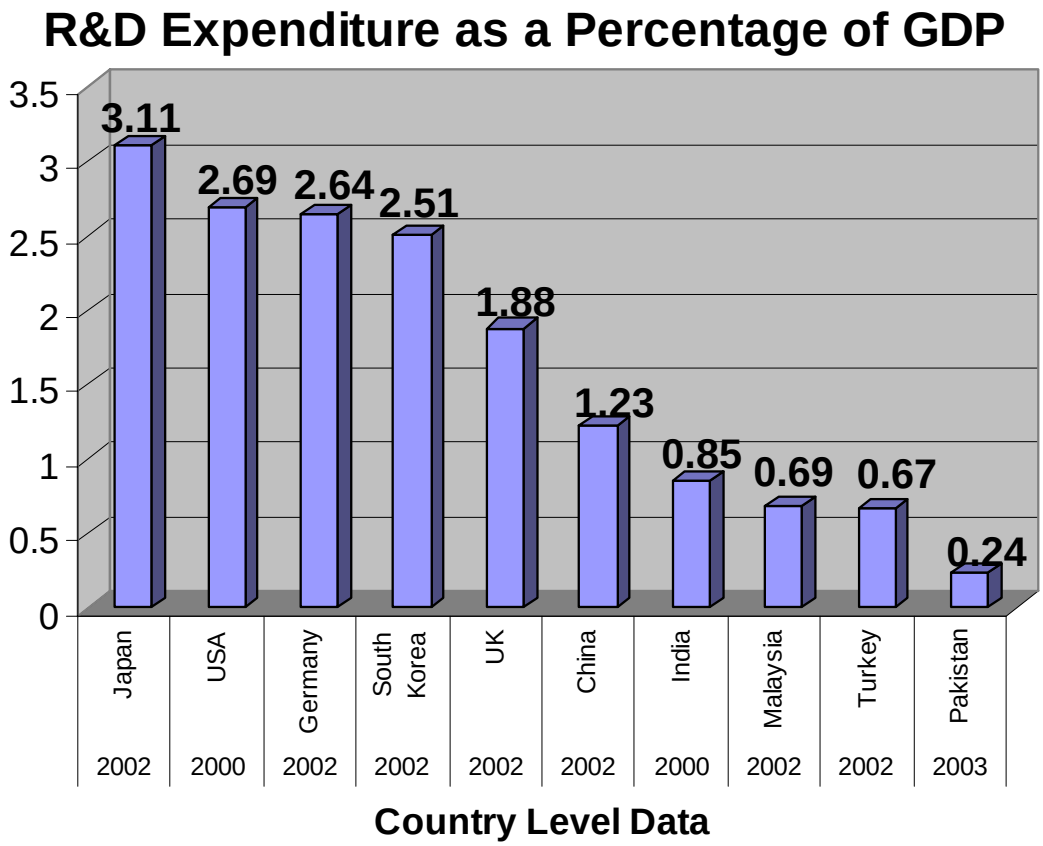
## Appendix 1




Source: Pakistan Council for Science & Technology (PCST), (2005), "Science and Technology Policy Indicators of Pakistan", Islamabad.

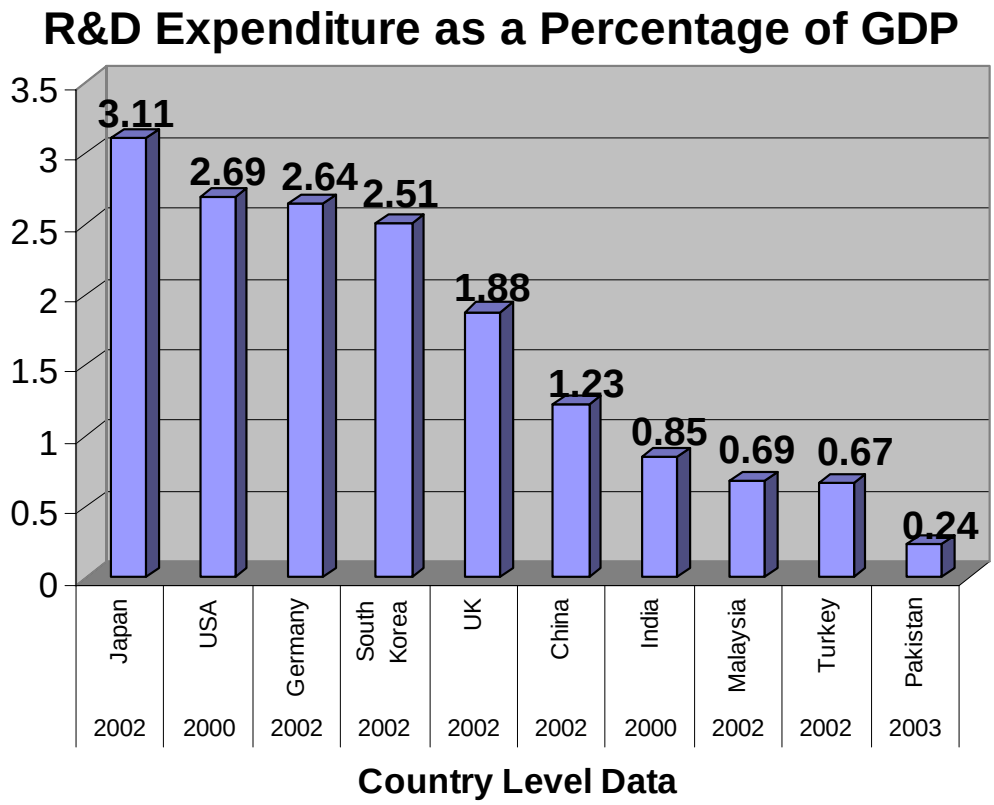
## Appendix 2
## Patent Statistics

**Number of Patents Granted in 2001**

| Country | Local | Foreign | Total | Ratio |
|---|---|---|---|---|
| **Pakistan** | **12** | **338** | **350** | **28.17** |
| **Egypt** | **57** | **373** | **430** | **6.54** |
| **Iran** | **529** | **352** | **881** | **0.67** |
| **Korea** | **21833** | **12842** | **34675** | **0.59** |
| **Japan** | **109375** | **12367** | **121742** | **0.11** |
| **China** | **5395** | **10901** | **16296** | **2.02** |
| **UK** | **3975** | **35674** | **39649** | **8.97** |
| **USA** | **87606** | **78432** | **166038** | **0.90** |
| **India** | **387** | ****** | ****** | ****** |

Source: World Intellectual Property Organization (WIPO), (2002).
** Data not available

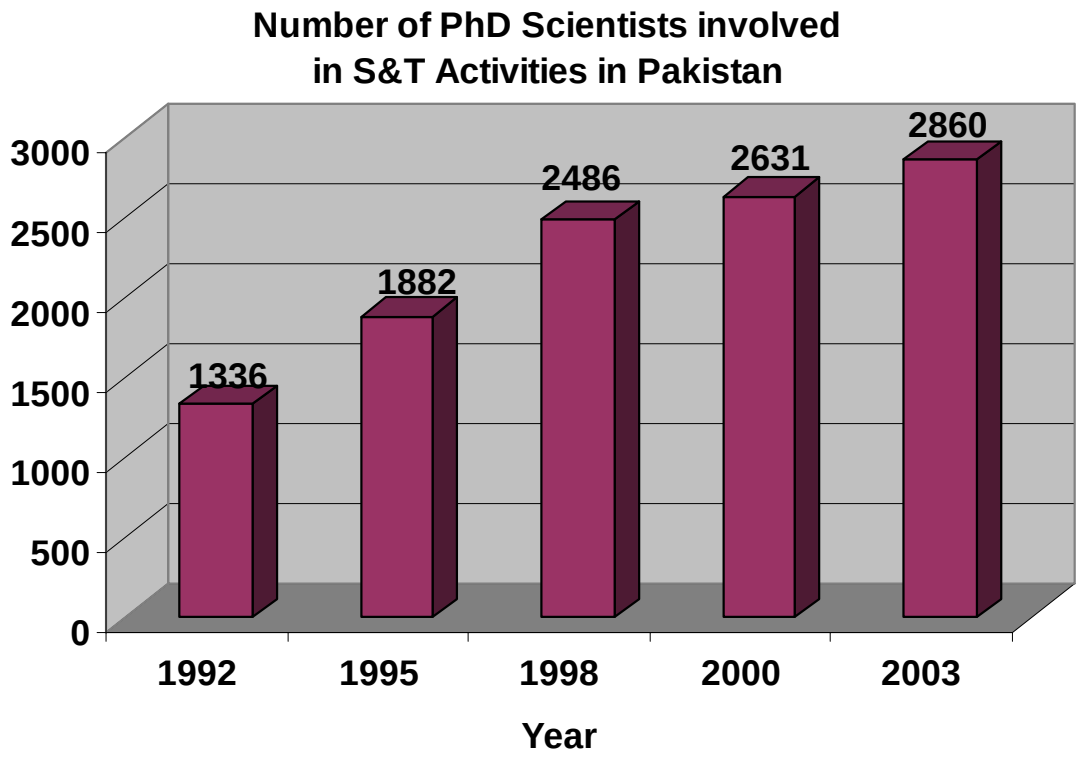
## Appendix 3




Source: Lall, S & Weiss, J, (November 2003), "Industrial Competitiveness: The Challenge for Pakistan" Background Paper for the Asian Development Bank Institute, *Policy Seminars on International Competitiveness in Pakistan*.

## Appendix 4

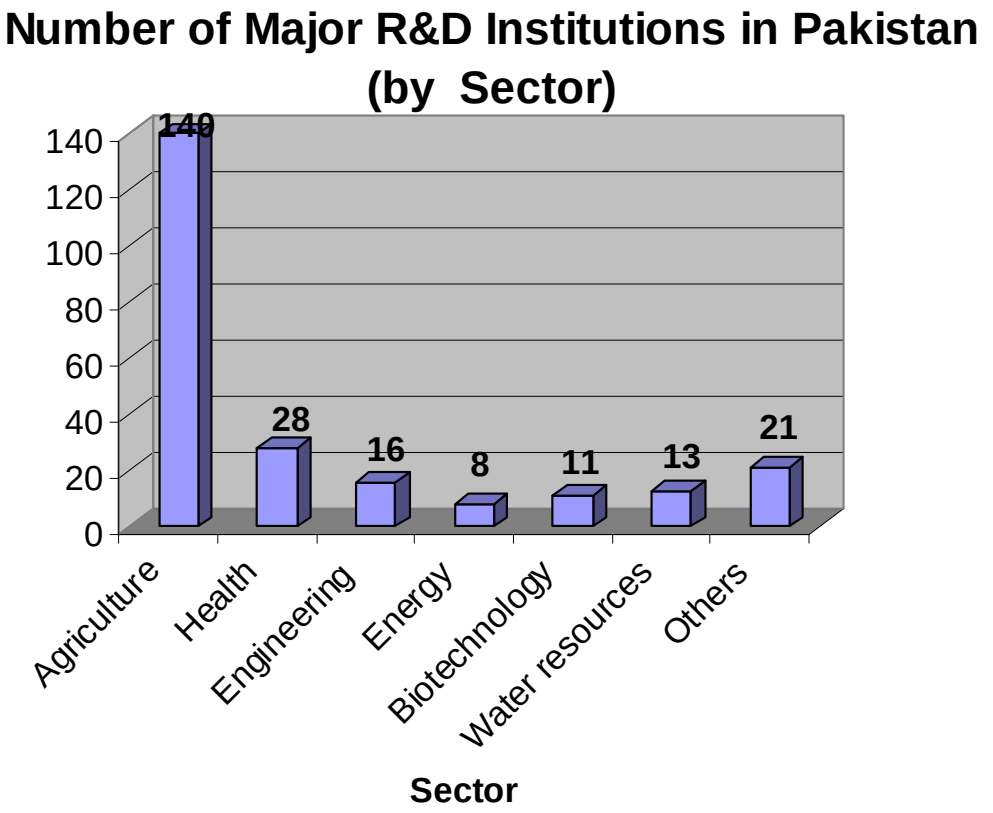
## Number of PhD Scientists involved in S&T Activities in Pakistan




Source: Pakistan Science Foundation (PSF)* and PCST data (2000, 2003)
*Directory A-Z (PhD Professionals in Science, Engineering & Technology in Pakistan), Pakistan Science Foundation, March 1998.

## Appendix 5

## Current Areas of Focus of R&D in Pakistan

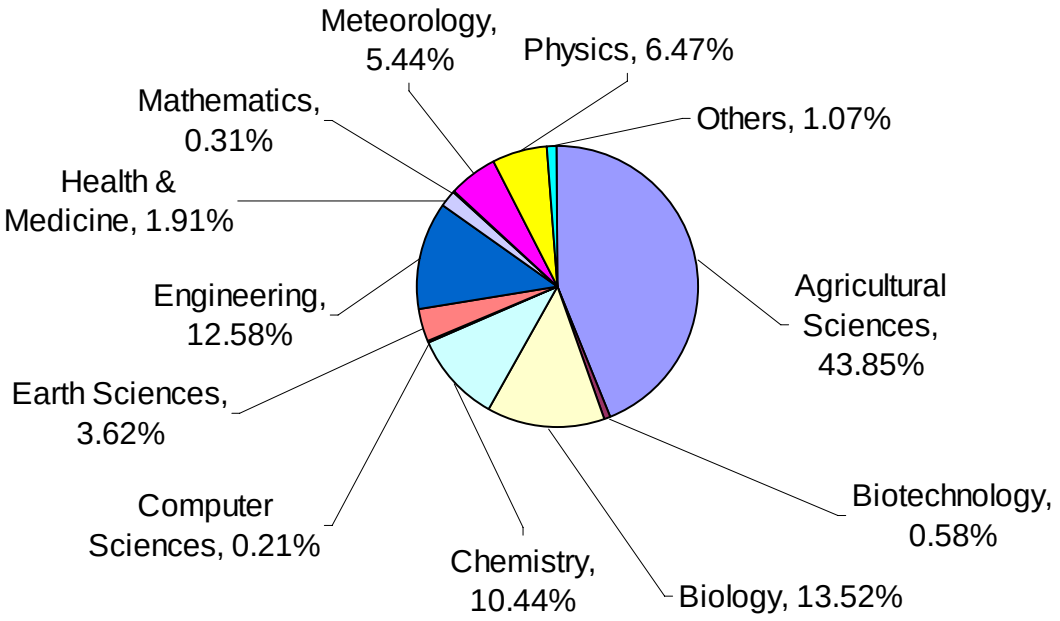



Other sectors include Electronics, Space, Meteorology, Road Transport, Telecommunication, Defence, Communications & Works and Oceanography

Source: Naim, S.T.K, (23 February 2007), "Mapping R&D in Pakistan", Pakistan Council for Science & Technology (PCST), Islamabad, Pakistan.

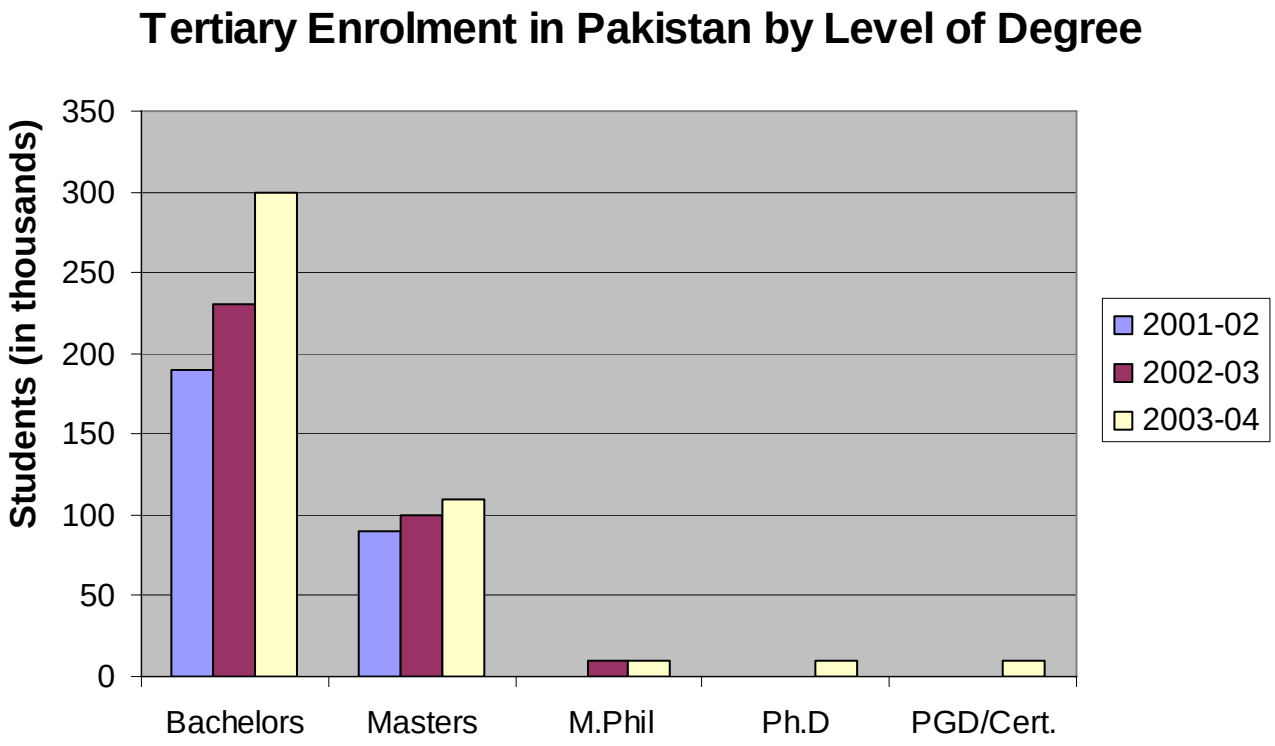
## Appendix 6

### Discipline-wise Distribution of Scientists working in R&D Organizations in Pakistan (2003)




Source: Pakistan Council for Science & Technology (PCST), (2005), "Science and Technology Policy Indicators of Pakistan", Islamabad.

## Appendix 7




Source: Higher Education Commission (HEC), Pakistan Institute of Development Economics (PIDE) & COMSTECH, (2005) "Technology-based Industrial Vision and Strategy for Pakistan's Socio-Economic Development".