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Gender Dimension of Science and Technology in Pakistan

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Abstract

Present paper discusses gender parity in relation to science and technology situation in Pakistan. About 27% of the scientists and engineers in Pakistan are women. The ratio of women in science has been reviewed in comparison to men by considering their number and ratio at different levels of education, science and technology manpower of the country and contribution to research and development (R&D) activities. This study also considers the representation of women in "Pakistan Academy of Sciences (PAS)", which is the supreme scientific organisation of Pakistan. It further highlights the contribution of women scientists and engineers in terms of patents, impact factor and journal citation index. Attention has also been drawn to disproportionately low numbers of women in science and technology and to sensitise educators, policy-makers and the scientific community of both genders that national socio-economic development cannot be realised without making the best use of all sectors of a nation's population.

Keywords: Pakistan, Science and technology, Gender disparity.

Introduction

Science and technology is part of almost every aspect of our lives. It is a known fact that no nation can develop without science and technology. It is not only associated with modernity, rather it is considered as an essential tool for achieving economic and social objectives. In the drive to strengthen knowledge-based societies and technological advancements, policy-makers are looking to ensure that their countries have an adequate supply of scientists and technologists. Unfortunately women in general do not have a strong presence in science and technology and despite the vital importance of the same for economic growth and social transformation the gender dimension of science and technology (S&T) has become an increasingly important issue worldwide.

The third of the millennium development goals emphasises gender equality and the empowering of women (Kabeer, 2005). The involvement of women in the advancement of knowledge base and the use of technology is essential if the millennium challenges are to be met. Gender bias is considered a confrontational apprehension in science with many studies reporting the uneven stratification of men and women throughout the scientific hierarchy (Zuckerman et al., 1991; Long, 1992; Loder, 2000; Bhattacharjee, 2004; Knapp, 2005; Muller et.al., 2005; Alper, 1993; Nonnemaker, 2000). No doubt, the number of women pursuing careers in science has increased globally in the past 20 years, despite these gains, research studies still reveal unreasonably low number of women in senior scientific and leadership positions (Luukkonen-Gronow and Stolte-Heiskanen, 1983; Northrup, 1988; Amato, 1992; Culotta, 1993; Kahn, 1993; Primack and O'Leary, 1993; Osborn, 1994; Sharma, 1994; HMSO,1994; Gender Working Group, 1995; Sonnert and Holton, 1996; Homberger, 1997; Subrahmanyan, 1997). Over the past two decades several initiatives are in place to increase the recruitment, retention and success of women in science (Loder, 1999; Dewandre, 2002) and there has been a strong move towards parity relative to men in many institutions and disciplines. However, in spite of this progress, there is still a long way to achieve gender equity (Loder, 2000; Nadis, 2001; Lawler, 2003; Bhattacharjee, 2004). The available data of UNESCO Institute for Statistics indicate that the countries that have achieved gender parity is despairing, and only a handful of other countries have more women researchers than men (Fig. 1). In Asia, women constitute only 18.9% of researchers, but there is considerable heterogeneity. It is encouraging to note that according to the most recent available data, Pakistan exceeds Asia average and equals to international average (UIS, 2012).

Women are 48.31% of Pakistan's total population (Pakistan Economic Survey, 2012-13). Despite constituting half of the population, women are an under-utilised talent. For realisation of national development goals, it is an economic necessity to fully utilise the talents of women at all levels of scientific and technological education, training and employment. The low socio-economic status of women in Pakistan is beginning to be recognised as a potentially significant drag on a country's growth (Bari, 2000). In a global gender gap survey of 136 countries, Pakistan is placed at

135 (Table 1), even behind Ghana and Ethiopia at 76 and 118, respectively. Similarly, in educational attainment Pakistan is ranked at 129 even behind Algeria at 106.

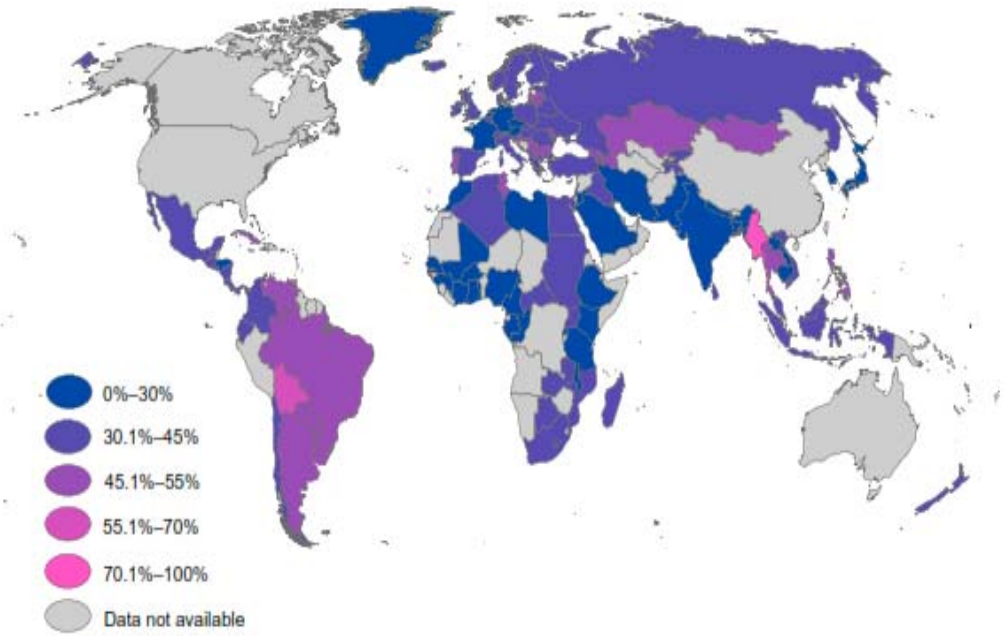

Fig. 1. The Gender gap in science: Women as a share of total researchers, 2010 or latest available year.
Note: Data in this map are based on HC, except for Congo and India based on Full Time Equivalent (FTE).

Table 1. Gender Gap Index of Pakistan 2009-2013.

Gender Gap Index	Overall		Economic participation		Educational attainment		Health and survival		Political empowerment	
	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score
2013 (out of 136 countries)	135	0.546	135	0.311	129	0.768	124	0.956	64	0.149
2012 (out of 135 countries)	134	0.548	134	0.31	129	0.762	123	0.956	52	0.164
2011 (out of 135 countries)	133	0.558	134	0.345	127	0.778	123	0.956	54	0.155
2010 (out of 134 countries)	132	0.546	133	0.306	127	0.77	122	0.956	52 0	0.155
2009 (out of 134 countries)	132	0.546	132	0.34	128	0.747	128	0.95	55	0.146

Source. The Global Gender Gap Report 2013 (World Economic Forum).
http://reports.weforum.org/global-gender-gap-report-2013/#section=country-profiles-pakistan

If we look at the situation of education in Pakistan at higher level, enrollment in the public sector professional colleges and public sector universities, it may be observed that the total number of students in public sector professional colleges was 289,000 with 38% female students and 62% male students (Pakistan Education Statistics, 2011-12 AEPAM). Women remain seriously under-represented in most disciplines of science and technology. Furthermore, they are not well-represented at the most senior levels in all disciplines. The job options for women remain limited to agriculture, services (domestic) and small-scale industries (Siddiqui et al., 2006). However, statistics also show a significant improvement in women's participation overall in SET-based education, training and employment over the last decade. All scientists and engineers require increased role in a knowledge-based society.

This paper attempts to report new empirical findings from a systematic and detailed analysis of data from different national and international sources. It also helps to assess the gender gap that prevails at all levels of science and technology related activities in Pakistan.

Results and Discussion

Pakistan is committed to achieve millennium development goals, including, elimination of gender disparity at all levels of education in near future. The medium term development framework (MTDF) 2005-10 makes a serious effort to include gender concerns in its strategies and overall sectoral programmes. Gender disparity in literacy and enrollment is one of the key focuses of the government. In Pakistan, status of women has improved in recent years but gender inequality remains pervasive. Gender parity is obvious at tertiary level of education from the latest available data as shown in Fig. 2. This data reflects that the number of females in 2006-07 enrolled for masters is 46.29%, with almost equal percentage (46.59%) in 2007-08 and a decrease in 2008-09 (41.72%). In Bangladesh and India, this number is 36% (2006) and 48.58% (2004-05) respectively (UGC, 2014, NSSO, 2001). In 2003, majority of students (60%) enrolled in Iranian universities were women (Golnaz, 2003). In 2008-09, women earned about 60% of MS degrees in US (NSSO, 2001).

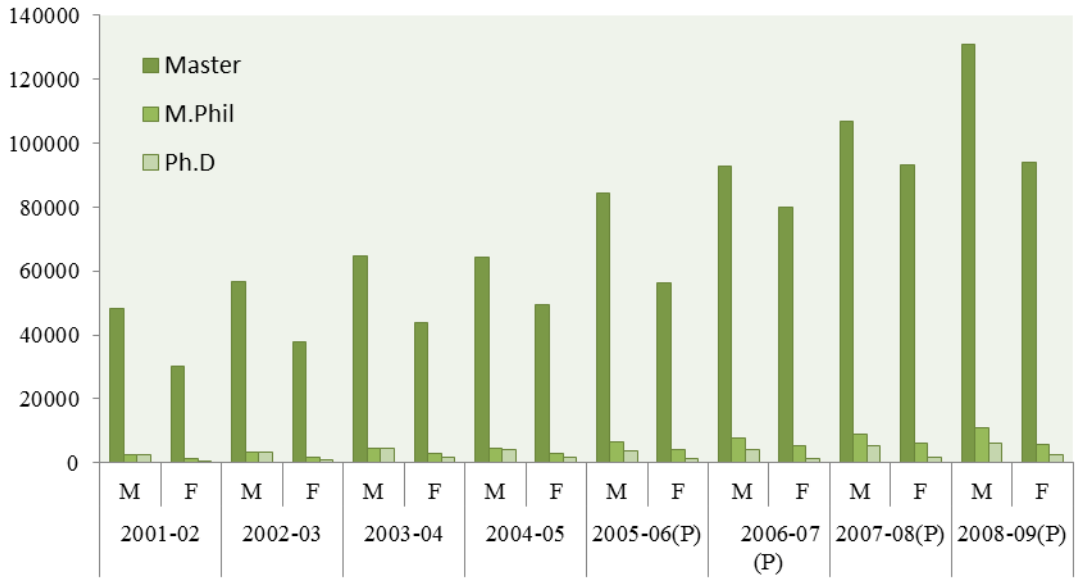

Fig. 2. Gender-wise enrollment at Universities/DAI (including constituent colleges) by level of degree during the period 2004-05 to 2008-09.

Source. Higher Education Commission, Pakistan, Available at http://www.hec.gov.pk/InsideHEC/Divisions/QALI/Others/Pages/EnrollmentbyGender.aspx

Being at the highest level of qualification, the PhD degree holders are considered to be of critical importance with respect to research and development. Although women are continuing to make-up an increasing proportion of all doctoral degrees awarded, the distribution is uneven. The available data from 12 countries of Asia shows that a total of 27,450 doctoral degrees have been awarded in 2004 out of which only 45.67% were in science and engineering (S&E) (CGS, 2012). Doctoral degrees earned by females in S&E remained quite low (17.43%) as compared to males (82.56%). In Iran, only 20.74% doctoral degrees were awarded in science and engineering, with 89.53% to males and only 10.46% to females. Although, the number of PhDs produced in Japan and South Korea was quite high but the percentage of doctoral degrees earned by females in S&E for 2004 was only 17.06% and 16.11%, respectively. In 2009, the women earned about 47% of all research doctorates in US; most of the growth in the number of doctorates earned by the women has been in S&E fields (NSF, 2010). The women earned 42% of S&E doctorates awarded in 2009, up from 29% in 1989. There are 6807 graduates produced by Pakistani universities upto 2010; 76.25% of which are males and 23.74 % are females. The percentage of PhDs produced in science is more than half (57.17%) as compaared to PhDs in other disciplines. During the years 2004 to 2010, a total of 2050 PhDs in science disciplines have been produced by Pakistani universities. 1509 (73.60%) of these PhDs were males and 541 (26.39%) were females (HEC, 2013a).

The research of these PhDs was supervised by scientists and engineers working in the R&D organisations and Higher Education Institutions (HEIs) of Pakistan. According to HEC data, a total of 1919 (1642 Males and 277 Females) scientists/ engineers have been enrolled as approved supervisors for PhD research (HEC, 2013b). Mostly, the PhD research is being done in the disciplines of science, with 1692 supervisors in science and

technology and only 227 in social sciences. The data of science and technology supervisors reveals that 1471 (85.56%) of these are males while only 221 (13.06%) are females. If this is compared with the social scientists, the percentage of females supervising the PhD research is relatively higher (24.66%). If the data of PhDs awarded in various science disciplines is considered from the years 2004-05 to 2009-10, only 790 scientists and engineers out of 1692 that have registered as HEC approved supervisors have actually supervised the PhD research work, with only 98 (12.4%) females.

However, the number of PhDs produced has increased over the last decade; accordingly the growth in the number of scientists involved in R&D per million populations has also increased (Fig. 3).

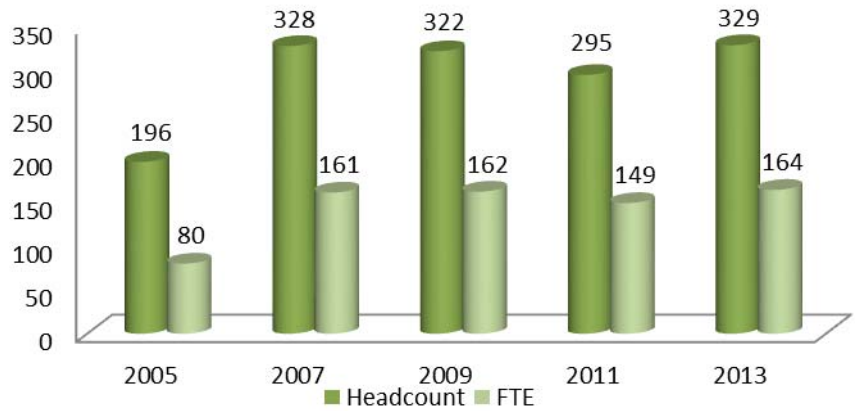

Fig. 3. Number of researchers (headcount and full-time equivalent) per million population in Pakistan (2005-2013).

Source. PCST R&D Surveys, Pakistan Economic Survey 2012-13.

Though Pakistan has accomplished a good level in terms of having female researchers equal to international average but the country has still to improve the level of gender parity by encouraging women participation in S&T related activities. The number of female researchers in Pakistan has increased from 18% in 2002 to 27% in 2008 (UIS, 2013, PCST, 2009). Pakistan exceeds Asian average and equals to the international average with regard to the percentage of female researchers (Table 2). According to a UNESCO Institute for Statistics (UIS) study of 103 countries with available data, women represent slightly more than one-quarter of researchers. In 40% of these countries, they represent less than one-third. Only about 17% of countries have achieved gender parity, and only a handful of others have more women researchers than men.

Table 2. Women's share of the total number of researchers (headcount), 2003.

Country	Women's share (%)		Country	Women's share (%)	
Argentina	51		**Republic of Korea**	11	
Bangladesh	14	U, 7	**Malaysia**	34	F, 2
Belgium	28		**New Zealand**	39	1
Brazil	46	U, 4	**Pakistan**	18	(2002) 27% (2008)
Colombia	37		**Russian Federation**	43	
Denmark	28		**Saudi Arabia**	17	2
France	28		**Sri Lanka**	25	U, 0
Germany	12		**Sudan**	30	4
India	10	U, F, 8	**Turkey**	36	2
Japan	12		**Kazakhstan**	49	F, 2

* The reference year is 2003 unless otherwise specified:
4: 2004, 2: 2002, 1: 2001, 0: 2000, 9: 1999, 8: 1998, 7: 1997, 6: 1996, U: UIS estimation

Highly qualified women are employed in the universities and R&D institutions. Previous studies indicate that gender equality in employment in Muslim majority countries remains under-explored (Syed, 2008). Also, it is illustrated from data that the current proportion of female faculty in universities

across the world almost never exceeds 25% (Lie et al., 1994). The statistics of faculty working in the higher education institutions and in S&T organisations by field of science, designation and sex (head count) is given in Figs. 4, 5 and 6, and shows gender parity in all disciplines and levels.

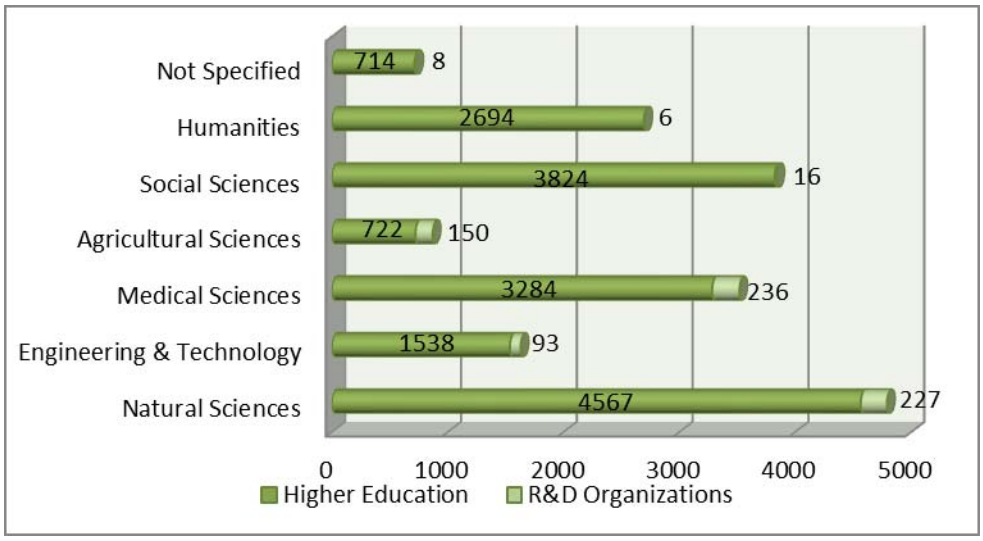

Fig. 4. Number of female researchers (headcount) by field of science and sector of employment (2013). Source. PCST R&D Survey 2013-14.

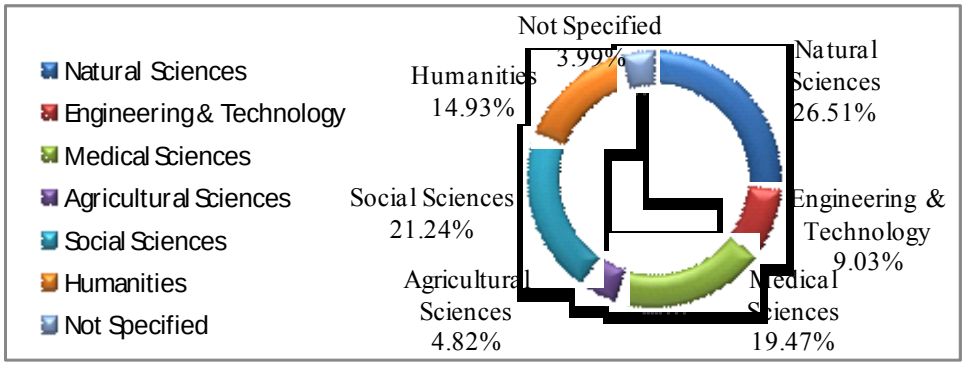

Fig 5. Percentage of female researchers (headcount) in different fields of science (2013). Source. PCST R&D Survey 2013-14.

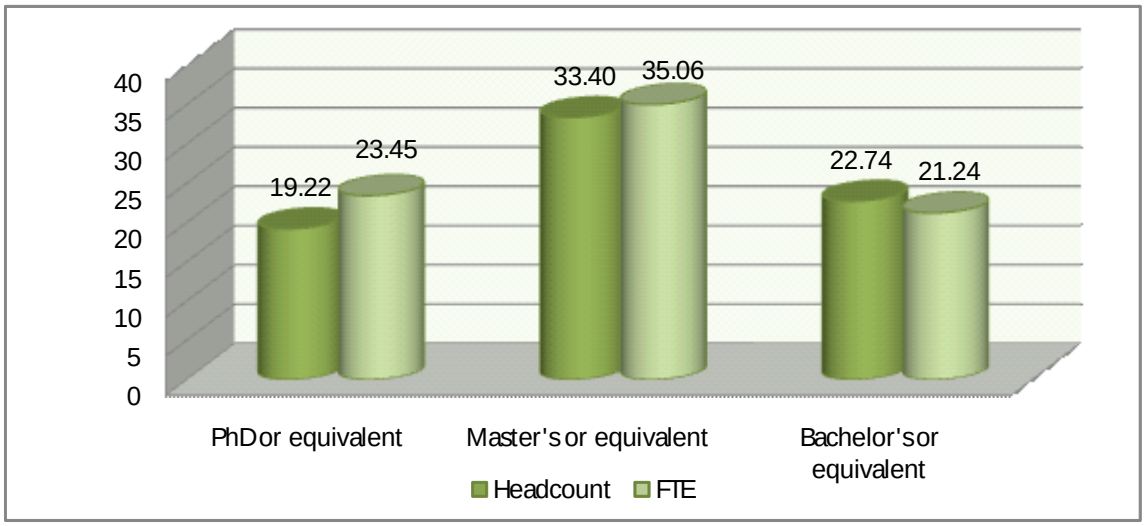

Fig. 6. Percentage of female researchers (headcount and full-time equivalent) in different qualification levels (2013). Source. PCST R&D Survey 2013-14.

The British governmental report "The Rising Tide (1994)" indicates that women are sorely under-represented in public appointments on key councils and boards responsible for developing policy in

science, engineering and technology-related fields: women made up only 12.8% of 917 public appointments on which they reported (HMSO, 1994). A report on Russian women scientists found that of 600 full members of the Russian Academy of Science, only 10 were women (Homberger, 1997). In India in 1993, of the 628 and 698 scientists chosen as Fellows by the Indian National Science Academy and the Indian Academy of Science, respectively, only 12 and 15 were women (Sharma, 1994). In the present study, it has been found that the Pakistan Academy of Sciences (PAS) is the supreme scientific organisation in science in Pakistan and utmost importance is attached to the membership of this academy, as only scientists of the highest merit, who have made outstanding contributions to the advancement of scientific knowledge, are elected its Fellows. The academy is governed by a 17-member Council, with a President, two Vice Presidents, Secretary General, Associate Secretary General and Treasurer. At present, there are 87 Fellows, 22 Foreign Fellows and 8 Members who have been elected by its General Body. It is found that no woman scientist has ever been elected as president, secretary or secretary general of this organisation (PAS, 2013). Presently, no female is a member of the council. Out of 11 members only 2 are women. As compared to 96.15% males, only 3.84% females are presently Fellows of the academy. This data clearly represents a serious under-representation of women scientists in this important organisation which is a repository of the highest scientific talent available in the country and is generally supported and consulted in all matters relating to scientific education, research and development.

An important indicator of scientific research is the research productivity of scientists/engineers, measured according to the internationally accepted criteria of impact factor and citation index. Numerous studies have found that female scientists publish at lower rates than male scientists, and research efforts to explain this gender gap have been largely unsuccessful (Long and Mary, 1995; Ward and Linda, 1995; Zuckerman, 1991). A symbolic payment for the work of researchers is a citation to their article when it is used by future researchers. It was found that women performed less well than did men in terms of citations (Davenport and Snyder, 1995; Gonzalez-Brambila and Veloso, 2007). These two factors are determined by the Pakistan Council for Science and Technology (PCST) for the award of Research Productivity Award (RPA) every year. If we consider the data of the scientists and engineers who apply for this award, from the year 2004-05 to 2009-10, the cumulative author impact factor is 2,893.189 while cumulative citation index is 14,400.14. If both males and females are considered the situation is not very encouraging as the percentage of cumulative author impact factor for males is 88.85, while for females it is only 11.14. Similarly, the citation index for males is 89.96, while for females it is only 10.03. The results of data for RPA regarding different aspects are shown in Figs. 7, 8 and 9, and Table 3.

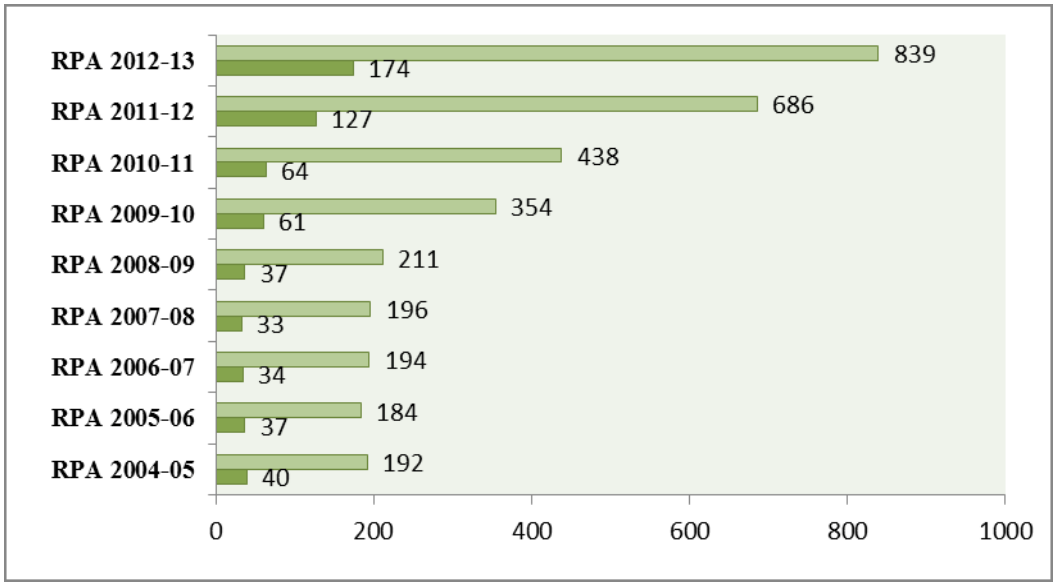

Fig. 7. Number of female and male scientists/engineers awarded RPA from 2004-05 to 2012-13.

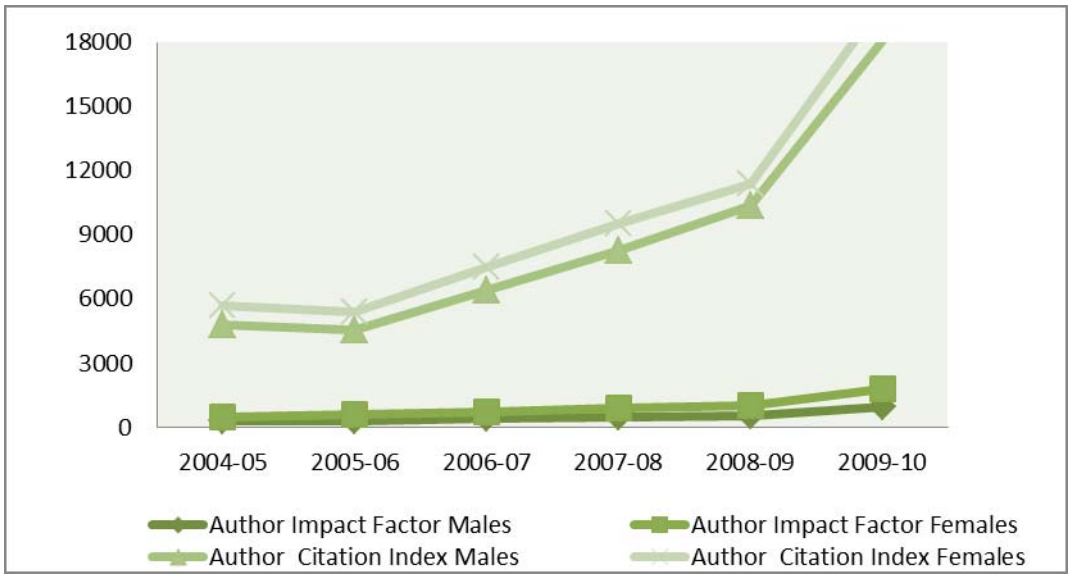

Fig. 8. Comparison of impact factors and citation indices of female and male scientists/engineers of Pakistan.

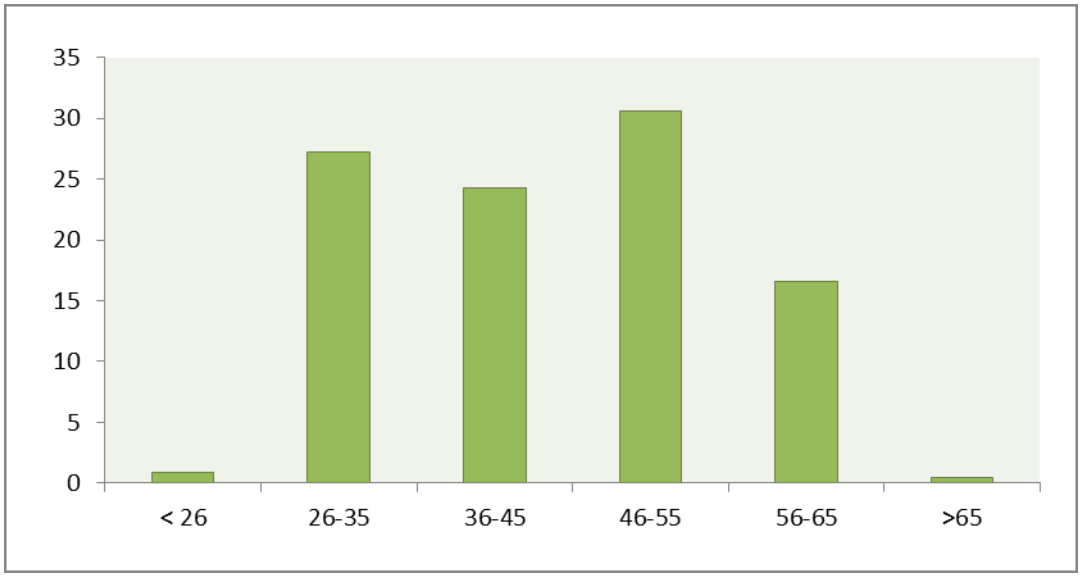

Fig. 9. Average age-wise Award of RPA to female scientists/engineers from 2004-05 to 2009-10.

Table 3. Discipline-wise Award of RPA to female scientists/engineers from 2004-05 to 2012-13.

Year	Agri	Bio	Chem	Earth Sci	Engg	Maths	Pharm	Phys	Comp	Stats	Health	Envi. Sci
2004-05	2	13	20	0	0	0	1	4	0	0	0	0
2005-06	0	12	21	0	0	0	1	2	0	0	1	0
2006-07	0	11	19	0	0	0	1	2	0	0	1	0
2007-08	0	10	18	0	0	0	2	3	0	0	0	0
2008-09	1	9	20	0	0	1	1	4	0	0	1	0
2009-10	3	18	28	0	0	1	4	7	0	0	0	0
2011-12	3	44	59	0	0	6	3	10	0	0	0	2
2012-13	11	64	68	0	0	8	3	12	0	0	3	4

Note. RPA was not awarded in 2010-2011.

Patents provide incentives to individuals by offering them recognition for their creativity and material reward for their marketable inventions. Like scientific publishing, women tend to patent less

than their male counterparts (Morgan et al., 2001; Bunker et al., 2005). Patent applications filed by public research organisations and local and foreign firms are an indication of the dynamism of innovation. For both India and Pakistan, patent applications from non-residents are much higher than those filed by residents (WIPO, 2013). If we consider the data of patents granted by Intellectual Property Organisation of Pakistan, a total of 1525 patents have been granted during the period 2005 to 2010 (IPO, 2012). Most of the patents are granted to the companies and organisations. If we consider only the data for patents granted to individuals/ group of researchers who are Pakistani nationals, this number is 56. The data reflects that women scientists apply for patents at a fraction of the rate of men. A total of 132 researchers have worked for these patents, solo in some cases and jointly in the others. If the output of female researchers is considered, the ratio of males to females who get patents granted is 3:1 (Fig. 10).

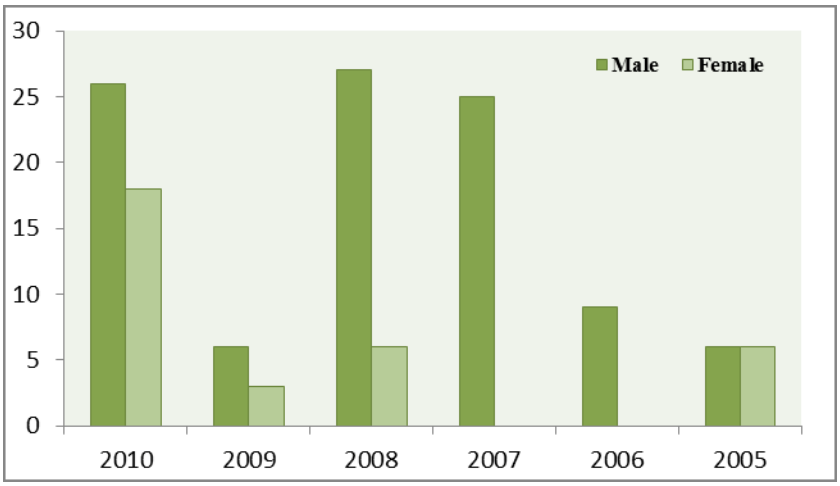

Fig. 10. Patents granted to female researchers as compared to men during the period 2005 to 2010.

Conclusion and future prospects

Better female contribution in science and technology should no longer be looked at only from the viewpoint of gender equality but as a prospective asset for national socio-economic development. The present study clearly reflects gender disparity in S&T education as well as in employment opportunities.

It is important not only to identify the current status of Pakistani women in science and technology but to devise policies and programmes that could sustain greater involvement of women in this field.

It is the need of time to make educational institutes more responsive to the needs of the women by establishing cells/units in colleges and universities to oversee the effective implementation of gender based government policies and programmes and to provide guidance and counseling in academic, financial, social and other matters to women. Policies are needed to ensure that women's education gives them the tools they need to be competitive in the job market. Thus the focus of these policies should be on achieving "gender equity" that can only be realised by the outcome of more equal representation, rather than on merely promoting the study of science. Another important factor in achieving these reforms will be a greater presence of women in decision-making bodies of science.

Initiatives are required to increase the recruitment, retention and success of women in science and technology. Keeping in view, the religious, social and cultural barriers that may hinder the education and careers, an adequate social infrastructure and policy environment should be provided by the government to facilitate women's entry into the fields of science and technology.

Governments need to provide an appropriate policy environment which helps women to balance family and professional responsibilities. This support may be for the professional, personal and family needs of women through their education, career development and their employment.

Policies should focus the areas including a childcare subsidy for working mothers, and accommodating their needs as wives and mothers. A programme of establishing re-entry scholarships and bridging courses will provide "second chance" opportunities for women to re-enter their chosen profession, to recommence study even after getting married and child bearing. Also, a fellowship scheme can be introduced for women who have children, thereby enabling them to come back, work and re-establish themselves in their field. This will save a large potential from getting wasted.

Women's empowerment through science and technology requires changes both at the individual

level and that of society. It is, therefore, not only the responsibility of the government to provide an appropriate policy environment fostering women in scientific community, but also civil society organisations need to share the process of change by the initiation of the public awareness campaigns. These campaigns will help in achieving the goal of gender parity by helping to improve understanding of the effects of gender harassment and by developing strategies to remove the impediments to women in S&T education, training and employment. This will help to promote women in science and technology.

As there is not much available data on statistics of women representation in science and technology, there is a dire need for cross-national database to fully understand the gravity of the gender issues as well as to use this data in policy making.

Immediate steps may be required to bridge the gender gap in science and technology as leaving all the problems to women or their employers will only worsen the situation. Understanding the informal obstacles, which women face in scientific endeavors can help to improve the situation, however the underlying causes for gender differences in science and technology require an in depth study.

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