

Gendered Science: Trends and analysis of contributions of Indian Women Scientists

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Abstract

All the major world organizations have recognized the vital role that a woman plays in educating the entire family & also in maintaining its health in a developing country. Indian women have excelled in almost all fields they are storming Information and Technology field, the number of women in computing and internet industries has registered a sharp rise. While presenting the hardcore figures about the women's enrollment in higher education system in different faculties; relative presence of women as scientific and technical staff in various institutions; recognition by various reputed national agencies; motivation and constraints to opt for science are also focused in this study. As an output Indicator, Publication analysis of Women scientist has also been presented.

1. Introduction

The world cannot afford the loss of the talents of half of people if we are to solve the many problems which beset us," said the eminent American scientist and Nobel Laureate Rosalyn Yalow. Obviously, she was referring to the women who form half, if not the better half the population of the world. Science and technology have been an integral part of Indian civilization and culture. At a glance, women in general might look like one of the many housewives – simple, docile, unassuming and humble. But behind this simple straight face is a razor sharp brain, and an eerie ability to execute, to convert thought into action without much ado. Over the years, in India women have overcome the traditional mindsets and have excelled in professions like teaching, medicine and pure sciences. Women have made important contributions in all walks of life and made inroads into new fields like engineering and information technology. Of the women science graduated 88 % of the science degree holders are in pure science, 8% in medicine and 3% in engineering and technology [1]. However, there has been a recent spurt of women joining the engineering and information technology fields, scientific or medical entrepreneurship [2]. Every year, girls do far better than boys, in science and arts, in the Class X and Class XII examinations. In some institutions, the majority of the toppers are girls [3]. But, even before they reach the point of choosing a career in science, women have to make difficult choices. There are great concerns now being shown in India about careers for women in science in the sense how to nurture their talent by facilitating and providing various options. To encourage women scientists as well as inspire girls and women to take up science careers, several schemes are being put in place.

Mention may also be made of a group of twelve Indian women scientists, who gathered and formed an association called "Indian Women Scientists' Association" (IWSA) more than 26 years ago in 1973 near Mumbai, with objectives of promoting and nurturing talents of women scientists. Now is having over 1400 women scientists from different parts of the country, with eleven active branches in cities like Delhi, Pune, Bhopal, Roorkee, Hyderabad, Lucknow, Kalpakkam, etc. Regularly meetings, conferences and seminars that highlight issues that affect woman scientists as well as scientific issues that affect women are organized. ISWA gives awards, honours, and scholarships to deserving candidates every year [2]. Besides, the 'Women Scientists Scheme (WOS-A)' of the

Department of Science and Technology is aimed to provide opportunities to women scientists and technologists for pursuing research in frontier areas of science and engineering [4].

1.1. Present Study :Purpose

The present study has been taken up with a view to focus on achievements and recognition of Indian Women scientists. Recognition of science can be judged on the basis of variety of factors, such as ability to secure permanent faculty position, attract research grants and research scholars, publications and patents, invitations to speak in conferences, travel fellowships, invitations to be on various policy making and review committees, awards, academy fellowships, etc. While many of these criteria depend upon the scientists' visibility and recognition by peers, the publications criteria is the objective one. While presenting the hardcore figures about the women's enrollment in higher education system in different faculties; relative presence of women as scientific and technical staff in various institutions; recognition by various Indian Academies; motivation and constraints to opt for science are also focused in this study. The study has been addressed from two perspectives Input Indicators and output Indicators. The purpose was to ascertain as to how prolific the women scientists are. Various trends in publication output in relation to institutions, subject areas, authorship pattern, core competencies and preferences have been attempted for analysis and conclusion drawn.

2. Methodology

The data for input indicators have been gleaned from various sources which have been duly acknowledged. The data for output indicators such as publication output have been gleaned from Web of Science (WOS) - Science Citation Index Extended for a 10 year period (1995-2004) for all areas in Science and Technology covered by WOS. Data was collected for each year for Country 'India' which included all document types in English language. The downloaded data included addresses (organisation and sub-organisation) to help correct identification of the respective authors for all the authors of each publication, besides other bibliographical details. Since it was not possible to identify the names of women authors from the WOS, as such the names were taken from various documents from the concerned institutions. The women authors in this study may be henceforth taken as scientific/technical personnel in all the areas of science and technology. The names thus obtained were cross checked from the publication list to identify the publication output trend. It may however be indicated here that the number of papers might be more here as each scientist (all the women scientists contributing a paper) has been credited with a paper irrespective of any number of authors. Hence if three women scientists have contributed a paper 'x' each of them has a paper to their credit. Therefore instead of once, the paper 'x' will have 3 times rendering in this study. The data thus obtained was subjected to analysis and the figures obtained are highlighted below. It may also be mentioned that the scope of institutions covered here in this study is limited to CSIR (around 40 labs/institutes and 37 field stations/ zone labs/regional centres); ICMR (25 permanent institutes, Regional Medical Research Centres and some advanced centres); IITs (7); and Indian Institute of Sciences Bangalore -institution of higher learning of national importance. These institutions (CSIR) are representative of science and technology; Medical (ICMR) and Engineering & Technology (IITs) and Institution of Higher learning (IISc) [5-7]. The credibility of identifying these institutions as samples for the present study is corroborated by the sample taken from WOS for each of the 10 year period to view ranking of the institutions that is being indicated in the analysis part.

2.2. Limitations

The study has limitations in terms of sample size because the data has been extracted from ONLY WOS, comprehensiveness of the data pertaining to women scientists and also duplication of records to a very limited extent.

3. Observations ,Data Analysis and Results

The Quantitative data on women studying science Vs those practicing science- particularly research , reveal the following. While the numbers (the study conducted by INSA [8]) reflected by some studies indicate in a over five decade period between 1950/51-2000/01, growth of student enrollment in University. There has been almost steady growth in percentage of women enrollment in each decade from 10.9% in 1950/51 to 39.4% in 2000/01. The percentage increase over the time period shows that while between 1950-51 to 1960-61, 1960-61

to 1970-71, 1970-71 to 1980-81, 1980-81 to 1990-91 the increase is 5.3%, 5.8% and 5.2% respectively, which is pretty much steady growth on an average of 5.4%. However in a decade marking 1990-91 to 2000-01, it has almost doubled registering 10.2% which definitely is a positive side of the coin.

At Undergraduate (UG), Post Graduate (PG) and Ph.D, level proportion of women participation is no way sizably low. However as we march up the ladder for higher positions as part of the Career Development programme, these figures don't correspond. In terms of faculty enrolment in Universities also, some growth in the percentage has been observed over the years. The figures pertaining to the years 1995-96 and 2000-01 indicate that in the area of science, of total faculty enrolment 37.0% and 39.4%; Medicine 39.8% and 44.0%; Agriculture 14.3% and 17.4%; Veterinary Sciences 18.0% and 20.9%; Engineering & Technology 16.0% and 21.5% respectively. This means there is a percentage increase of 2.4% in science; 4.2% Medicine; 3.1% Agriculture; 2.9% Veterinary Sciences; 5.5% Engineering & Technology from the block year 1995 to 2000-01. The trend shows that there is definite growth in enrolment of women faculty ranging between over 2% to over 5% between 1995 and 2000-01 with maximum in the area of Medicine and Engineering & Technology. This could be also interpreted in the sense that more women in science opt for in Engineering and Medical fields.

At the same time if we look at the enrolment of women students we find that in 1970-71 and 1995-96 there is a decrease in enrolment of Girl students in Science by 5.6% in 1995-96; but increase of 1.1% in Engineering and Technology and .2% in others (Agriculture, medicine, vet sciences, etc) in 1995-96.

Looking at the figures of School enrolment in various countries, in India the percentage girl students in primary enrolment is 45.2 and secondary enrolment is 39.8 [10]; while for USA and Sri Lanka, the figures are 49.7 & 50; and 49.5 & 52% respectively. Regarding level wise (Graduate, Post-Graduate and PhD) percentage of female student enrolment in India in various subject areas, the figures depict - in science stream 39.0, 42.5, 37.2; Engineering & Technology 21.8, 15.8, 16.5; while in Medicine 45.5, 34.4, 29.3 at graduate, post-graduate and PhD levels respectively.

Table :1 States with > 50-% women enrolled in University

State	Science	Eng/technology	Medicine	Agric.	Vet.
Goa	59.8	25.9	61.1		
Kerala	64.7	30.5	54.7	54.4	45.4
Punjab	55.4	19.1	56.0	28.8	-
A&N	54.5	-		-	-
Chandigarh	63.3	24.9	57.3		
Pondicherry	52.7	28.8	46.8	-	41.3

Table :2 States with < 35% women enrolment in University

State	Total	Science	Eng/technology	Medicine	Agric.
Arunachal Pradesh	29.7	33.0	13.5	-	-
Bihar	21.1	21.3	11.8	20.2	25.2
Jharkhand	30.5	26.9	6.8	33.8	29.6
Orissa	34.6	28.9	18.6	23.7	29.2
Rajasthan	32.6	39.2	11.4	24.2	10.1

Table :3 Large Universities with <20% or > 40% Women

University	% women
Bihar, BB Ambedkar	19.6
Veer Kumar Singh	19.8
Gujrat-MS Univ.	45.5

Mumbai	50.5
Allahabad	18.0

Source: INSA Report on Science Career for Indian Women

Amongst the states with >50-% women enrolled in University, the states who have outpaced the others in terms of enrolment are Kerala followed by Chandigarh in science; Kerala followed by Pondicherry in Engineering & Technology; Goa followed by Chandigarh in Medicine; while in Agriculture and Veterinary Sciences it is again Kerala. This trend clearly shows that only state in India with almost 100% literacy rate leads to better understanding of the educational values, thus %age of women enrolment from this state of India corroborates to this evidence. Therefore it is likely that higher the literacy rate of a nation, greater the wisdom and awareness among masses regarding choice of appropriate career for themselves [9].

In states with >35-% women enrolled in University, the overall scenario depicts that Orissa state takes the lead with 34.6% enrolment. While large universities where %age of women enrolment is either >20 or <40; the strikingly encouraging figures are for Mumbai University, capturing 50.5% (slightly more than half population) of the total enrolment population and MS University, Gujarat with slightly less than 50% (45.5%)[9].

While touching some of the leading scientific organisations where the core research activities in the different subject areas are carried out, the following scenario about involvement of women scientists is projected as reflected below. Also to obtain a glimpse of the trend in institutions of higher learning as a sample, only a few universities have been included to showcase the position.

Table :4 Women Scientists in Various Organisations

Organisation	Scientists % women	Technical % women
CSIR	13.0	14.0
DBT	31.8	23.1
ICMR	27.3	20.1
DAE	16.5	-
DOD	8.7	-
ICAR	20.1*	-

* Asst. Prof =10.4; Assoc. Prof.=6.2 & Prof.=3.5

Table :5 Women Faculty in Universities : An illustration

Organisation	Scientists % women	Technical % women
IISc	16.3	14.7
Hyd.Univ	15.8	23.1
JNU	16	0

In Indian Institute of Sciences (IISc), Bangalore the Scientists and technical personnel come under academic and scientific cadre, which have been clubbed together in the above table, under scientists and technical for clarity and uniformity purposes. However the actual numbers obtained from INSA study are: 6.6% scientists, 14.7% technical under academic cadre and 9.7% scientists in the scientific cadre. For the Hyderabad University (Hyderabad University) and Jawaharlal Nehru University (JNU) the figures are only for science departments and schools. This does focus on a very important point that women pursuing a science career, reaching to higher positions in the cadre in their career could be few and far between.

3.1. Recognition and Rewards

In spite of the fact that there are many women who have done exceedingly well in their scientific and academic pursuits, not many are seen being awarded and rewarded. To cite an example of the type the prestigious Academy fellowships to the leading Academies of India namely Indian National Science Academy (INSA), New Delhi; Indian Academy of Sciences (IASc), Bangalore and National Academy of Agricultural; Sciences (NAAS), the percentage of Women Fellows are abysmally dismal with INSA 3.2, IASC 4.6, NAAS 4.0.[8]

One of the most prestigious awards by Council of Scientific and Industrial Research (CSIR) is Bhatnagar prize. Out of 333 awards since 1958, only 8 women have received it ,up to 2004; while none in last 6 years including 2004. This means only 2.4% of women scientists could be considered for recognition for this award. Similarly there has been no significant representation by women scientists on the top positions. There are sporadic instances here and there, one of the leading scientific departments (DBT) was headed by a women scientist as its Secretary, Government of India. But such instances are few and far between. Coming to the younger generation of the scientific community, out of 468 young scientist awardees since 1974 –2005, women awardees are only slightly over 9. %. [11]

The other aspect as an output measure was the publication output. The data gleaned for the purpose is reflected below. In all 186,029 papers were downloaded for a 10 year period. The institutional sample analysis, revealed that the institutions identified for the present study contributed reasonably good proportion of the total publication output in each year. The analysis sample included only 2000 records for each year (due to limitation of the database) where minimum threshold was kept 20 records and top 100 results were fetched. The numbers in column 4 gives institution name value(s) outside display options. This substantiates the view that the institutions covered here are some of the leading establishments in the country from where substantial research output is generated This was to showcase the integrity of the institutional sample used in the study.

Table :6 Publication Output from India as Reflected in Web of Science
For the Years 1995-2004

Year	Total No. of Records (India)	Proportion of Records from Selected Institutions *				Institution's Outside Display Options
		CSIR	ICMR	IISc	IIT	
1995	16,365	4.50%	1.6%	4.50%	9.70%	967
1996	16,474	5.60%	1.20%	6.20%	9.60%	1008
1997	16,261	5.60%	3.30%	4.80%	10.70%	1038
1998	17,724	5.00%	3.20%	4.60%	9.70%	1135
1999	15,676	4.50%	1.20%	4.00%	10.10%	1249
2000	17,496	6.80%	3.20%	4.70%	8.80%	1278
2001	19,245	5.80%	3.40%	4.60%	9.70%	1273
2002	20,375	5.50%	3.20%	5.40%	9.70%	1303
2003	23,115	4.70%	3.50%	4.70%	9.30%	1451
2004	23,298	6.50%	3.70%	3.90%	12.00%	1447

*based on analysis of 2000 publications sample for each year

Table:7 Institution-wise Contributions of Women Scientists: Indicators At A Glance

Institutions	No. of Units	Records for Women Scientists	Number of* Unique Authors contributing papers in column 3	Proportion/Author
CSIR	40 Laboratories/Inst. 37 Field stations/Regional centres, etc	1305	293	22.45%
ICMR	25 Permanent Institutes/Regional Medical Research Centers	894	181	20.25%
IISc	1	637	57	8.94%
IIT	7	1075	146	13.58%

*Number covered in this study.

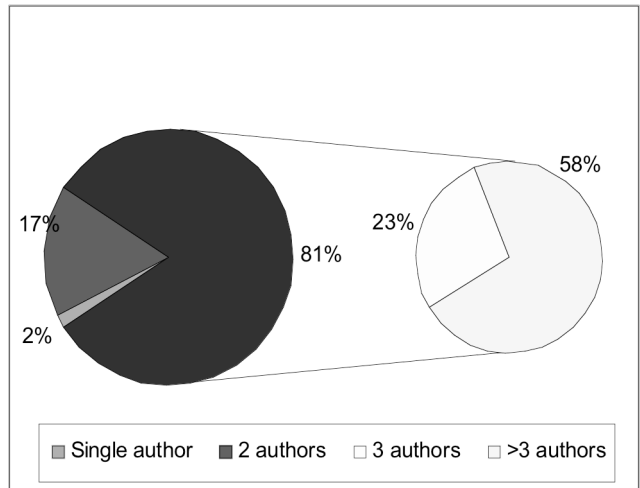
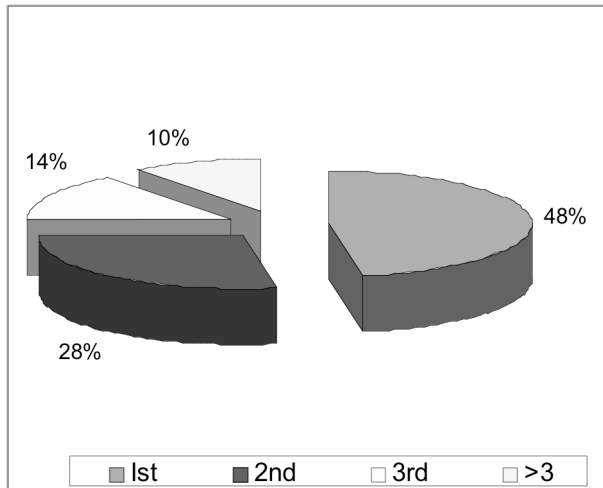
The publication data pertaining to the research output of women scientists of these institutions project the following scenario:

Figure 1: Authorship Indicators at A Glance

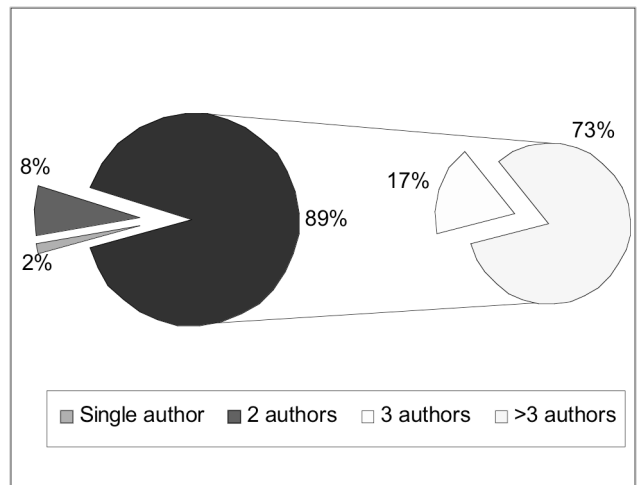
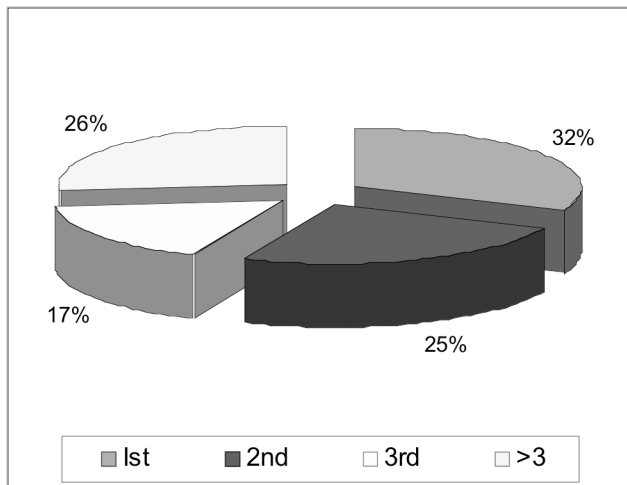
[A] Rank of Scientists (women) Amongst Total Authors Contributing A Paper

[B] Authorship Pattern of Papers Contributed by Women Scientists

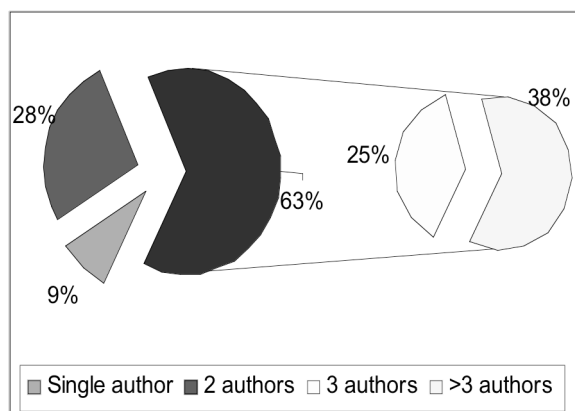
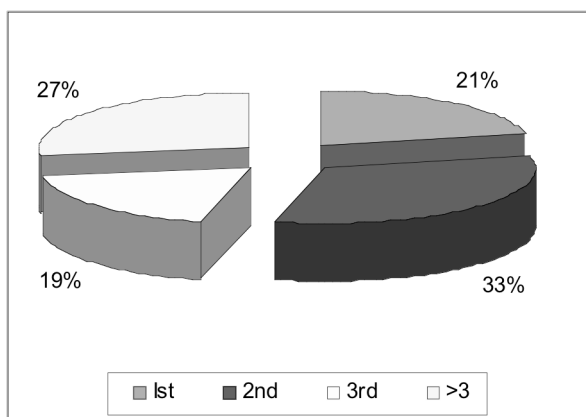
CSIR



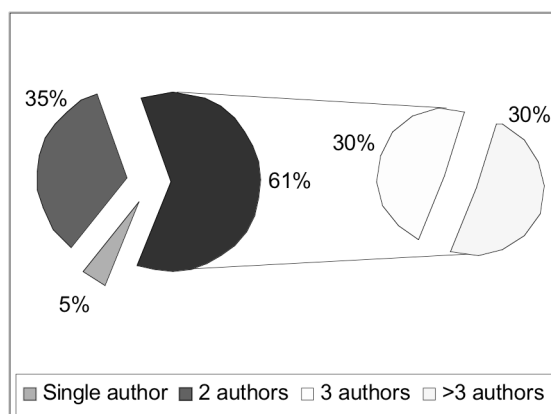
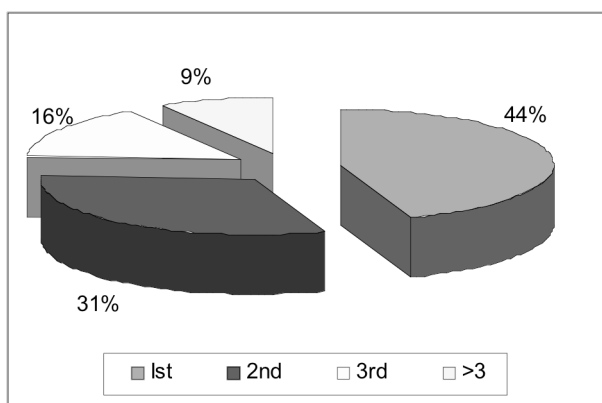
ICMR



IISc



IIT



The analysis reveals the following : About 13% of the total output from CSIR group of institutions has been contributed by women. Over 95% of papers where women scientist is the Ist author is contributed by multiple authors in case of CSIR. 3 authors having > 10th rank in the serialization of the authorship list (appearing between 10-11 th rank). As per the authorship pattern goes ≥ 2 authors contribute 51.80%; ≥ 3 authors 24.09%; and $\geq 4 = 10.13\%$ respectively.

In case of ICMR over 98% of Ist women authored paper contributed by multiple authors . Around 11% of women scientists are either Ist or 2nd author. Over 10 authors having > 10th rank in the authorship list (between 10-19 th rank). 69 papers are authored by > 10 authors (between 10-22 authors). Over 56% of women scientists are either Ist or 2nd author.

Over 91%of women authored paper contributed by multiple authors in case of IISc, Only 1 author having ≥ 10 th rank in the authorship list (11th rank); 128 authors having > 5th rank in the authorship list (between 5-11 th rank). 1 paper authored by > 10 authors. > 2 authors have contributed 63.11%; > 3 authors 38.46%; $> 4 = 18.05\%$ and > 5 (b/w 5-11 authors) 20.41% papers respectively. About 37% of women scientists are either Ist or 2nd authors..

The figures for IIT shows that over 95%of women authored paper contributed by multiple authors. only 1 authors having 10th rank in the authorship list (14 th rank); 31 authors having > 5th rank in the authorship list (between 5th-14 th rank). Only 3 papers authored by > 10 authors (between 10-14 authors); > 2 authors contributed = 95.25%; ≥ 3 authors 60.83%; $\geq 4 = 30.42\%$ and > 5 (between 5-27 authors) 14.76% respectively. Over 39% of women scientists are either Ist or 2nd authors

4. Results and Key Findings of Study

- The overall general scenario points out that higher the literacy rate of a state, greater the wisdom and awareness among masses regarding choice of appropriate career for themselves
- This does focus on a very important point that women pursuing a science career, reaching to higher positions in the cadre in their career could be few and far between.
- Many women have done exceedingly well in their scientific and academic pursuits, not many are seen being awarded and rewarded.
- As predicted by the statistics, approximately over 90% of the cases, women scientists believe in collaboration, as indicated by the authorship pattern.
- Proportion of being >2nd author is less, women scientists are generally appearing as 1st or 2nd author. Hence generalization like, leading the research front at different levels cannot be overlooked.
- Around 15-20% contributions come from women scientists irrespective of their proportion in the organization in that cadre. The indicators point towards a very important aspect (though a generalized one) that in terms of the output, the women scientists are fairly standing at a reasonably virtuous platform with whatever putative limitations, where input indicators are far from matching levels.

Some putative factors influencing science career for women as reflected in INSA study also generally attributed to :

- (i) Personal –family, motherhood and Inadequate support systems; (ii) Societal/Cultural that could be due to fixed mind set, restriction on movement, nepotism and sexism, etc.
- (ii) In the same study the figures regarding professional growth, career advancement shows that 33% Scientists and 28% students were not satisfied. The reasons cited were lack of time; household responsibilities; organization did not encourage; ill health; lack of finance (for students) perhaps attributed to impact of globalization, privatization.
- (iii) So far as the denial of career Options, and its consequences are concerned the study shows that 35.6% Scientists had denied themselves career options and 22.7% of such denial affected adversely their career. While 20.3% of the respondents being denied promotion, and among them 42.3% attributed it to gender bias, and 50% to lack of connections. Regarding the limited recognition about 50% have mentioned appropriation of women's work.

Remedial measures to improve women's participation in science needs to be addressed at the earnest . If some of the core issues are addressed, it is most likely that one may find the proportion of women participation steadily going up. Though over the years that is happening (at a considerably slower rate) that can be attributed to some shift in the cultural outlook and societal attitude.

The parameters focus on strong flavor of gendered science. Something solid, stringent and serious needs to be thought of and done. The necessary measures to address the issue of gendered science needs to be taken up by the authorities. A final word, the study is only a beginning in bringing together input and output factors. In order to generalize and corroborate to findings particularly for the output indicators, a bigger sample and major project needs to be undertaken to overcome the major limitations regarding sample type and size as faced in this study.

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