Chapter V

INPUT PARAMETERS

The various demographic and biological input parameters used in the probability model as well as in the simulation model are derived from empirical studies, survey or census data, and are presented in this chapter. Sources of data or method of derivation, wherever necessary, are also included. To begin with, all India population and the age distribution of currently married females in the age group 15-44, used for the study, are presented.

5.1 BASE POPULATION

The 1981 census has revealed that the population of India is 685,184,692 as on 1st March 1981. Accordingly, the total number of currently married females in the age group 15-44 is reported to be approximately 115.776 million. Single year age distribution of the currently married females were not available at the time of the present analysis. Hence the available quinquennial age distribution of the currently married females based on five percent sample data is used to derive single year age distribution of currently married females in the age group 15-44 (see Table 5.1). This forms the base population for projecting the currently married females for the present study.

Table 5.1 : Single Year Age Distribution of Currently Married Females in the Age Group 15-44, India, 1981

Age	Married females	Age	Married females
15	1,620,864	30	4,468,953
16	1,852,416	31	4,283,711
17	2,315,520	32	4,121,626
18	3,473,280	33	4,005,850
19	4,399,488	34	3,890,074
15-19	13,661,568	30-34	20,770,214
20	4,700,505	35	3,751,142
21	4,839,437	36	3,635,366
22	4,932,058	37	3,542,746
23	5,001,523	38	3,426,970
24	5,047,834	39	3,311,194
20-24	24,521,357	35-39	17,667,418
25	5,001,523	40	3,172,262
26	4,978,368	41	3,079,641
27	4,932,058	42	2,987,021
28	4,769,971	43	2,871,245
29	4,631,040	44	2,732,314
25-29	24,312,960	40-44	14,842,483

5.2 AGE AT MARRIAGE

The initial probability distribution of first marriage was derived from a distribution of age at first marriage of Indian women. At the 1981 census, the question on age at marriage was canvassed for all ever married women (Govt. of India, 1983). The distribution of age at marriage of only currently married females is used here to derive approximately the probability of marrying at different ages and is presented in Table 5.2.

5.3 ESTIMATION OF ANNUAL MARRIAGES

To project currently married women in 1981 into future years, the ratio of new entrants into marriage in a year to currently married females in the age group 15-44 in the preceding year, has been used (see Chapter IV). This ratio is approximated by the ratio of new entrants through marriage into the currently married women aged 15-44 in the same year. To estimate this ratio it is necessary to obtain annual marriages that occur in the country.

In the absence of reliable data from the Civil Registration System, it is difficult to obtain annual marriages that occur in the country. This can however be obtained indirectly in a number of ways (Venkatacharya, 1972). The method used here is as follows :

Table 5.2 : Probability of a Woman Marrying at Age y (in years)

Age (y)	Probability	Age (y)	Probability	
15	.4650	26	.0030	
16	.1100	27	.0025	
17	.0995	28	.0025	
18	.0810	29	.0025	
19	.0805	30	.0005	Mean=16.965
20	.0640	31	.0005	Vari-ance=6.875
21	.0505	32	.0005	
22	.0145	33	.0005	
23	.0097	34	.0003	
24	.0073	35	.0002	
25	.0050			

To estimate annual marriages the number of women marrying at different ages in a year needs to be obtained. This can be done by applying the Montras method (United Nations, 1949).

Let m_x be the proportion of females surviving to x^{th} birthday who have married for the first time in their x^{th} year of age .

Let s_x be the number of single (never married) women surviving at the x^{th} birthday

Let f_x be the number of females surviving to x^{th} birthday

Then $$m_x = \frac{s_x}{f_x} - \frac{s_{x+1}}{f_{x+1}}$$

In other words,

m_x = (proportion of single women at age x) - (proportion of single women at age x+1)

The number of marriages at age x in a year thus can be obtained by

$$M_x = m_x f_x$$

The total annual marriages are obtained by summing over x in the above equation.

The above computations were done making use of age,

sex and marital status distribution as well as single year age return of female populations for India for the census years 1971 and 1981. Since the estimates are based on unsmoothed data, they can vary from their true value, depending on the error of age reporting. It is found that the ratio of newly married women in a year to the currently married women in the age group 15-44 in the same year for the census year 1971 and 1981 is estimated to be around 5.4 percent and 5.7 percent, respectively. The corresponding figure for the census year 1961 was reported to be 6.1 percent (Venkatacharya, 1972), indicating that this has ranged between 5 and 6 percent over the three decades. Thus, a value of 5.5 percent is considered to be a satisfactory one for the period of projection.

5.4 LEVEL OF MORTALITY

The present study is concerned with the period 1981-96. The SRS estimate of the expectation of life at birth (e_o^o) for males (54.1 years) and females (54.7 years) for the year 1980, is taken as the base for determining the course of mortality in the country during 1981-96. The annual increase in e_o^o per year has been assumed to be 0.50 year for males and females during the period of projection (for details of mortality assumptions see Government of India, 1984). The levels of mortality assumed for males and females during 1981-96 are shown in Table 5.3.

Table 5.3 : Expectation of Life at Birth (e_o^o) for Males and Females for the Period 1981-96.

Period	e_o^o Male	Female
1981-86	55.6	56.2
1986-91	58.1	58.7
1991-96	60.6	61.2

Source: Govt. of India, 1984. Population Projections for India 1981-2001. Census of India, 1981. Series-I India, p.9, Office of the Registrar General, New Delhi.

5.5 PROBABILITY OF A BIRTH TO SURVIVE TO AGE x

The survival probability of a male and female birth to exact age x (x = 1, 2, ... 30) could be derived from l_x column of a life table. Having selected the level of e_o^o for males and females, the corresponding l_x/l_o values are computed from the result of a paper by Sinha (1972) which provides complete life tables based on Coale and Demeny's Model (West) Life Tables. Table 5.4 presents the survival probability of a male and female birth at different ages, for the first thirty years. The probability of death of a male and female birth in the first x years of life can obviously be obtained by subtracting the corresponding survival probability from one.

Table 5.4 : Probability of a Male and Female Birth to Survive to Age x

Age (x)	Males (e_o^o = 54.6)	Females (e_o^o = 55.2)
1	.90143	.90661
2	.88164	.88354
3	.87292	.87324
4	.86720	.86646
5	.86293	.86127
6	.85977	.85791
7	.85709	.85492
8	.85480	.85227
9	.85281	.84989
10	.85103	.84773
11	.84937	.84571
12	.84774	.84374
13	.84607	.84176
14	.84429	.83966
15	.84234	.83740
16	.84018	.83492
17	.83777	.83220
18	.83512	.82926
19	.83223	.82613
20	.82912	.82284
21	.82570	.81939
22	.82216	.81576
23	.81839	.81199
24	.81455	.80811
25	.81070	.80416
26	.80687	.80014
27	.80304	.79606
28	.79919	.79191
29	.79528	.78766
30	.79128	.78333

5.6 LEVEL OF FERTILITY

To derive base level estimate of fertility for the present study, the 1981 census fertility data (Government of India, 1983) were used. The general marital fertility rate (GMFR) as well as the corresponding age specific marital fertility rate (ASMFR), based on the 1981 census fertility data, appear to be grossly underestimated. For example, as can be seen from Table 5.5, the level of GMFR was reported to be 150.4 per 1000 currently married women in 1981. The estimated birth rate based on census fertility data was found to be around 25.4 per 1000 population during that period. On the other hand, SRS data revealed birth rate of 33.3 during 1981. This clearly indicates that level of fertility reported in the form of GMFR and ASMFR in the census fertility data needs an upward revision.

In order to examine the extent of under-enumeration in the SRS birth rate itself, it is found that indirect estimate of birth rate, based on census analysis is 34.6 during 1976-81 as against 33.42 given by SRS for 1976-80 (Govt. of India, 1984). If it is assumed that the birth rate of 34.6 during 1976-81 is correct, the SRS birth rate figure of 33.4 for 1976-80 would need an inflation by a factor 1.0359 (34.6/33.4). Therefore inflating the SRS birth rate for 1981 (33.3 per 1000 population) by this

Table 5.5 : The Level of Birth Rate, General Marital Fertility Rate and Age Specific Marital Fertility Rate, India, 1981

Age group	Age Specific Marital Fertility Rate (per 1000 married women)	
	Observed	Revised
15-19	126.64	172.41
20-24	222.02	301.38
25-29	197.40	267.44
30-34	144.21	195.49
35-39	94.04	127.61
40-44	52.34	70.59
All ages (GMFR)	150.40	204.20
Birth rate (per 1000 population)	- (34.6)*	34.5 (33.3)**

* Indirect estimate based on census data analysis for the period 1976-81

** SRS estimate for the year 1981

Source: (1) Observed-computed from Government of India, 1983. Report and Tables Based on Five Percent Sample Data. Series-1, India, Part II - Special, Census of India, Office of the Registrar General, New Delhi, pp. 374 and 380.

(2) Revised-estimated by author.

factor, the level of birth rate in 1981 is estimated to be 34.5. The corresponding GMFR has been estimated to be 204.2, by dividing the birth rate by the proportion of married females in the age group 15-44 to the total population in 1981.

The above analysis clearly indicatesthat the GMFR figure of 150.4, as reported in the 1981 census fertility report, would need an inflation by a factor 1.35757 (204.2/ 150.4). Inflating the ASMFR reported in the census data by this factor, the revised ASMFR for the year 1981 are obtained and are presented in Table 5.5.

5.7 ESTIMATION OF AGE SPECIFIC FECUNDABILITY

For the present study, while generating fertility histories of the Indian women through simulation, age specific values were assigned to the fecundability parameter in the model to take care of the variation in fecundability of the women over age. In this context, two sets of age specific fecundability values, one inclusive of the effects of contraception and the other by removing the effects of contraception, were estimated from age specific fertility rate by the application of Sheps' model (1964), details of which and its application in Taiwan data can also be seen in a paper by Sullivan et al., (1976). Fecundability is defined as the probability of conception in a menstrual

cycle, provided the woman is biologically capable of reproduction and is in suceptible (cohabiting) state.

Using the notations in Sheps' model, fecundability can be expressed as :

$$\hat{\rho} = \frac{\hat{P}}{\left[(1-\epsilon)(1-\delta)\right] + \left[\hat{P}(1 - \sum_{i=2}^{5} \varphi_i \theta_i)\right]} \quad \ldots\ (1)$$

where,

$\hat{\rho}$ is the estimated fecundability value,

$\hat{P}$ is the monthly fertility rate for fecund women exposed to pregnancy,

δ is the gross induced abortion rate,

θ_2 is the gross early foetal wastage rate,

w is the gross late foetal wastage rate,

ϵ is the total foetal wastage rate $(\theta_2 + w)$,

$\theta_3 = w\ (1 - \delta)$,

$\theta_4 = (1 - \epsilon)\ (1 - \delta)$,

$\theta_5 = \delta(1 - \theta_2)$ and

φ_2, φ_3, φ_4 and φ_5 are mean infecund months associated with early and late foetal wastage, live birth and induced abortion respectively.

The values are known for all the independent parameters in the above equation for $\hat{\rho}$ and the value of P can be estimated from observed age specific marital fertility rates.

$$\hat{P} = \frac{F}{12}\left[\frac{1}{1-[S'+S''(1-S')]}\right] \quad \cdots \quad (2)$$

Where $\hat{P}$ is an estimated monthly fertility rate,

F is an observed age specific marital fertility rate,

S' is the proportion of women naturally sterile, and

S" is the proportion of women effectively protected by the modern methods of contraception.

Age specific values for F, S', and S", and all other input parameters in the equation 1 are presented in Table 5.6. The age specific fecundability values were estimated by five year age groups. As can be seen from equations (1) and (2), $\hat{\rho}$ provides the fecundability estimate, removing the effects of contraception and induced abortion. When the values of S" and δ are set at zero in the above equations, $\hat{\rho}$ provides fecundability estimate inclusive of the effects of contraception and induced abortion, and it is denoted by $\hat{\rho}'$. Table 5.7 presents age specific values of $\hat{\rho}$ and $\hat{\rho}'$ by five year age groups. Harmonic means of the two sets of age specific estimates range between .032 and .051 which agree well with expectations. They are consistent with other estimates obtained elsewhere (Singh and Pathak, 1968; Srinivasan et al., 1987). The age specific estimates are also consistent with observed marital fertility rates and with the highly effective use of contraception observed among older Indian women.

Table 5.6 : Parameter Values Used for Estimating the Age Specific Fecundability

Parameters	Age Group					
	15-19	20-24	25-29	30-34	35-39	40-44
1	2	3	4	5	6	7
Gross foetal wastage rate:						
Late (w)	.0625	.0207	.0201	.0131	.0473	.0106
Early (θ_2)	.1487	.1126	.0958	.1251	.1417	.2545
Total (θ)	.2112	.1333	.1159	.1382	.1890	.2651
Infecund months associated with:						
Early foetal wastage (ϕ_2)	5	5	5	5	5	5
Late foetal wastage (ϕ_3)	11	11	11	11	11	11
Live births (ϕ_4)	17*	18	20	22	23	24
Induced abortion (ϕ_5)	4	4	4	4	4	4

Contd .....

Table 5.6 : (Contd .....)

1	2	3	4	5	6	7
Gross induced abortion rate (δ)	.0088	.0112	.0178	.0193	.0152	.0095
Proportion naturally sterile (S')	.1110	.0320	.0320	.1110	.2690	.5070
Proportion effectively protected by contraception (S'')	.0022	.0511	.1906	.3034	.3800	.3380
Observed fertility rate (F)	.1724	.3014	.2674	.1955	.1276	.0706

* arbitrary

Source : w and θ_2 : see text, Table 5.9

ϕ_2 and ϕ_3: estimated from Tables 5.10 and 5.11 of the text

ϕ_4: estimated by author

ϕ_5: arbitrary

δ : estimated by author, based on 1981 MTP data published by Govt. of India, Ministry of Health and Family Welfare, New Delhi.

S' : see text, Table 5.8

S'' : Estimated by author, based on 1980 All India Family Planning Survey data (Khan and Prasad, 1983)

F : see text, Table 5.5

Table 5.7 : Age Specific Fecundability : India, 1981

Age Group	Estimated Fecundability	
	$\hat{\rho}$	$\hat{\rho}'$
15-19	.027	.027
20-24	.064	.057
25-29	.079	.050
30-34	.073	.035
35-39	.066	.027
40-44	.042	.022
Harmonic mean	.051 (.058)*	.032 (.036)

* Figure within parenthesis indicates arithmetic mean

Note: $\hat{\rho}$ provides fecundability estimate excluding the effects of contraception and induced abortion (i.e. when parameters S" and δ in the model are set to the rates observed in India), while $\hat{\rho}'$ provides fecundability estimate inclusive of the effects of contraception and induced abortion (i.e., when S" = 0, δ = 0).

5.8 ESTIMATION OF AGE SPECIFIC STERILITY RATE

The estimates of age-specific sterility rate are necessary along with other parameters to predict the reproductive performance of a female. Sterility or zero fecundability as a phenomenon refers, in a strict sense, to the inability of a woman to conceive, whether the cause of sterility is the husband or wife. Such estimates based on Indian data are scarce. Nevertheless, Yadava et al., (1982) recently provided an estimate of sterility rate based on North Indian data which were collected during 1978. The data on number of births to eligible couples in a fixed period of seven years preceding the reference data was used for obtaining sterility rates, corresponding to ages 19, 24, 29, 34, 39 and 44 years. The values of sterility rate at these ages are reported to be 0.0542, 0.0284, 0.0949, 0.1362, 0.3688 and 0.5823, respectively.

The above estimates of age-specific sterility rate are more or less consistent with other studies (Srinivasan et al., 1987) and are used here as input after splitting them into single year by fitting a second degree polynomial curve. They are presented in Table 5.8. The values first decrease with age, attain a minimum at the peak of the reproductive period and increase thereafter with age, first slowly and then rapidly. The higher value at the beginning takes care of adolescent (temporary) sterility present among teenagers, which decreases with age. The much higher value again at the

Table 5.8 : Age-Specific Sterility Rate, 1978

Age	Sterility Rate	Age	Sterility Rate
15	.165	30	.070
16	.137	31	.089
17	.111	32	.111
18	.089	33	.136
19	.070	34	.165
20	.054	35	.196
21	.041	36	.231
22	.032	37	.269
23	.025	38	.311
24	.022	39	.355
25	.022	40	.402
26	.025	41	.453
27	.032	42	.507
28	.041	43	.564
29	.054	44	.624

later stages of reproduction takes care of the high incidence of secondary sterility.

5.9 TYPES OF PREGNANCY OUTCOME

The estimates of the probabilities of a conception terminating in a live birth, a stillbirth, or an abortion, by age of mother are necessary as input probabilities. Based on the results of the Khanna study (Potter et al., 1965), the probability of a live birth, stillbirth and abortion by age of mother at conception is derived by Venkatacharya (1972). They are used here and are reproduced in Table 5.9.

5.10 PERIOD OF GESTATION

The period between date of conception and its data of termination is the gestation period. This period depends on the type of pregnancy outcome. Based on case histories of Naoroji Wadia Hospital, Bombay, Mukerji and Venkatacharya (1967) derived probability of termination of pregnancy periods for each type of pregnancy outcome. In the absence of other reliable data, they are adopted here and are reproduced in Table 5.10.

5.11 POSTPARTUM AMENORRHEA

Postpartum amenorrhea (PPA) is the period of non-susceptibility to conception following a pregnancy. Along

Table 5.9 : Probability of a Conception Terminating in a Live Birth, a Stillbirth or an Abortion

Age group	Live birth	Stillbirth	Abortion
15-19	.7888	.0625	.1487
20-24	.8667	.0207	.1126
25-29	.8841	.0201	.0958
30-34	.8618	.0131	.1251
35-39	.8110	.0473	.1417
40-44	.7349	.0106	.2545

Source: K. Venkatacharya, 1972. Reduction in Fertility due to Induced Abortions : A Simulation Model. Demography 9(3) : 352.

Table 5.10 : Distribution of Gestation Period by Each Type of Pregnancy Outcome

Period of gestation (in months)	Type of pregnancy outcome		
	Live birth	Stillbirth	Abortion
1	-	-	-
2	-	-	.15859
3	-	-	.34361
4	-	-	.26432
5	-	-	.13216
6	-	-	.10132
7	.00331	.25186	-
8	.02759	.34814	-
9	.34547	.40000	-
10	.57065	-	-
11	.05298	-	-
Mean	9.64	8.15	3.67
Variance	0.46	0.60	1.44

Source : S. Mukerji and K. Venkatacharya, 1967. Effect of Postpartum Amenorrhea on Natality, Population Simulation Models, Research Paper Series No.5, p. 5, IIPS, Bombay.

Table 5.11 : Distribution of Postpartum Amenorrhea Period Following a Live Birth Termination

Period of PPA in months	Probability	Period of PPA in months	Probability
1	.04	16	.03
2	.04	17	.03
3	.05	18	.02
4	.05	19	.02
5	.05	20	.01
6	.06	21	.01
7	.06	22	.01
8	.07	23	.01
9	.07	24	.01
10	.06	25	.01
11	.06	26	.01
12	.05	27	.01
13	.05	28	.01
14	.04	29	.01
15	.04	30	.01

Mean = 10.80

Variance = 46.09

Source : K. Venkatacharya 1970a.A Monte Carlo Model for the study of Human Fertility Under Varying Fecundability. Population Simulation Models, Research Paper Series No.30, IIPS, Bombay.

Table 5.12 : Distribution of Postpartum Amenorrhea Period Following a Stillbirth and an Abortion Termination

Period of PPA in months	Distribution of PPA following	
	Stillbirth	Abortion
1	.10	.60
2	.25	.30
3	.35	.10
4	.20	-
5	.10	-
Mean	2.95	1.50
Variance	1.25	0.45

Source : S. Mukerji and K. Venkatacharya 1967. Effect of Postpartum Amenorrhea on Natality. Population Simulation Models. Research Paper Series No.5, IIPS, Bombay.

with other factors, PPA depends on the type of pregnancy outcome. The suitable probability distribution of PPA associated with each conception termination are selected for use in the model and are reproduced in Tables 5.11 and 5.12. The probability of termination of PPA period following a live birth termination is derived by Venkatacharya (1970a) from the results of Khanna study (Potter et al., 1965), while the probability distributions of PPA periods associated with a stillbirth and an abortion termination are suggested by Mukerji and Venkatacharya (1967).