PROJECTIONS OF POPULATION, ENROLMENT AND TEACHERS

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WHY PROJECTIONS?

Planned economic development requires data about various aspects of socio-economic conditions at different levels. Indicators of development are directly or indirectly related to the size and structure of the population. It is, therefore, of paramount importance to know various aspects of the size and structure of population at different points of time. Another important requirements of educational planning is enrolment projections which forms the basis for many of the investment decisions. For example, new schools to be opened or upgraded and the number of teachers required are decided on the basis of the number of children to be enrolled. None of these tasks can be accomplished efficiently unless the planner has an adequate idea of how many students will enter the system, how they will proceed through various grades, and what number will graduate. This is ever more important keeping in view the requirements of programmes like District Primary Education Programme (DPEP) and Sarva Shiksha Abhiyan (SSA), which envisage developing plans in a decentralised mode, with an emphasis on disaggregated target setting. Therefore, an attempt has been made in this module to discuss and illustrate population, enrolment and teachers' projection techniques, with a focus on primary and upper primary levels of education.

PROJECTIONS, FORECASTS AND PREDICTIONS

Projections are conditional statements about the future. They refer mostly to the exercises of extrapolation of the past trends into the future; and they do not take into account changes in the policy parameters. For example, a projection of the future population growth may not be taking into account changes in the government health policies, family health programmes, etc. Projections are based on the assumption that the past trends will continue to operate in the future. The reliability and usefulness of projections depend on the assumptions and their closeness to reality. In the long run, the policy parameters are to be incorporated

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in the projections. The likely effects of policy changes are to be judged and projections are to be made accordingly. Thus, when an element of judgment is added to the projections, it becomes a forecast. Forecasts enjoy the advantage of being based upon the assumption or a set of assumptions which are likely to be realized in the near future and can yield a relatively more realistic picture of the future. In general, population projections are treated as predictions and are never to be termed as final population. They should be reviewed frequently in order to determine the degree to which they agree with recent demographic changes. If the discrepancies between the projections and the ultimate events are significant, it should be found out whether it is due to the quality of input data or due to the methodology adopted.

POPULATION PROJECTIONS

Detailed demographic data is generally not available at the block and district levels and hence it is not possible to undertake detailed population projection exercises at these levels. For example, the 2001 Census provides total population figures alongwith population in the age group of 0-6 years and sex distribution (age-group population has not yet been released by the Office of the Registrar General of India). This set of information is available both at the block and district levels. But to develop elementary education plans at these levels, information on a few other demographic variables is also required. Population in the age groups of 6-11 (6+ to 10+), 11-14 (11+ to 13+), 6-14 (6+ to 13+) years and single age-6 population are some such variables. Component method used to project these variables requires a basic set of demographic data, which is generally not available at the block and district levels. In the absence of the basic data, other alternative methods are used for projections which are based upon a number of assumptions.

The following steps are involved:

Step I. By using the compound rate of growth or ratio method, described below, project the total district population upto the year 2010. The district population should be projected annually as well as in the benchmark years such as 2005, 2010 etc.

Step II. On the basis of the available information, calculate the following:

- Percentage of 0-14 population to total population in the latest year;
- Percentage of 6-11 (6+ to 10+) population to total 0-14 population in the latest year;

- Percentage of 11-14 (11+ to 13+) population to total 0-14 population in the latest year; and
- Percentage of single age-6 population to total 6-11 year population in the latest year.

The above set of information is required for the latest year which can be obtained in a number of ways. To ensure the quality and reliability of data, the total, 0-14, 6-11, 11-14 and single age-6 population collected through the recent household survey conducted in the district can be used for this purpose. Alternatively for better reliability, the same can be computed on the basis of 2001 Census. In case 2001 Census detailed information is not available, percentages of 1991 Census may be used which should be treated as the last option. In that case, the projections would be based upon the assumptions that the 1991 percentages would remain constant throughout the period of projections. As percentages vary from district to district, district-specific percentages should only be used in the projections.

Step III. Apply percentage of 0-14 population calculated above (Step II) to the projected district population (Step I) to obtain projected 0-14 year population upto the year 2010 annually

Step IV. Apply percentage of 6-11 to total 0-14 population obtained in Step II to the projected 0-14 population (Step III) to obtain projected 6-11 population in different years

Step V. Apply districts' present sex ratio (number of females per thousand males) to the projected 6-11 total population (Step IV) to obtain male and female distribution of 6-11 population up to 2010

Step VI. Repeat Steps IV & V above, to obtain 11-14 year total population and its male & female distribution up to 2010

Step VII. Apply percentage of single age-6 population to total 6-11 population obtained in Step II to the projected 6-11 total population (Step IV) to obtain total single age-6 population up to 2010

Step VIII. Apply districts' sex ratio (latest) to the projected single age-6 (total) population (Step VII) to obtain boy and girl distribution of single age-6 population up to 2010

Step IX. Use the present (2001) percentage share of block to districts' total population in obtaining block-specific 6-11, 11-14, 6-14 and single age-6 population up to 2010 and its male and female distribution.

A spreadsheet using EXCEL/LOTUS can be developed which will be of help in carrying out projections at the block level. Any person having little acquaintance with the spreadsheet operations can develop the worksheet. The only point of caution is that for each set of projections, district-specific set of percentages is to be used. Similarly, within the district, block-specific percentages of 0-14, 6-11, 11-14 and single age-6 population should only be used. It would be better to separately undertake the exercise for male and female population which, in turn, be added together to obtain the total population.

POPULATION PROJECTION TECHNIQUES

There are various methods of projecting population (mathematical, economic and component methods). Some are very sophisticated and rigorous while others are simple and less sophisticated. Normally, population in future is governed by the following equation:

$$\mathbf{P_n = P_o + \text{Number of Births (B)} - \text{Number of Deaths (D)} + \text{Net Migration } (N_m)}$$

For the projection of population in 2011 (P_n), base year population (P_o) in 2001, the number of births and deaths between 2001 and 2011 and net migration is required. Keeping in view the in-migration and out-migration, net migration may be either positive or negative. Though population in the base year (2001) is available, number of births, deaths and migration in future needs to be projected which is not an easy task. One such method that considers all these aspects is known as component method of population projections. This method is suitable for projecting sub-national i.e. district and block level population. It requires detailed age-structure of population in the base year alongwith estimation of a variety of demographic indicators. For projecting age and sex distribution of population in 2011, distribution of population in 2001 in different age groups such as, 0-4, 5-9, 10-14 etc. is required. The same is then used with the birth and death rates to know age-specific mortality rates and fertility rate among the child bearing women population. Similarly, by using the appropriate life-tables, expectation of life at birth is projected. The data required by the component method is generally not available at the district level. Even if available, they are out-dated and their quality is also not reliable. Use of the method requires expertise in demography and understanding of the demographic structure of the population, which may not be available at the district level. Therefore, the module discusses simple and easy-to-handle methods of population projections given the purpose. Let us first consider the *growth rate method.*

For computing the annual rate of growth (simple), the following formula can be applied to the information at any two points of time.

$$r = \frac{1}{n}\frac{[Pn - P_o]}{[P_o]} x100 \qquad (1)$$

where

r = annual rate of growth

P_n = population in the current year

P_o = population in the base year

n = number of intermediary years.

Let population of India be given as 846 million in the year 1991 (P_o), as against 1,027 million in the year 2001 (P_n), then ‘r’ would be,

$$r = \frac{[1027 - 846]}{[846]} x100$$

r = 21.39% gives the decadal rate of growth which has taken place between the two given years, 1991 to 2001. The annual rate of growth can be simply obtained by dividing the decadal rate of growth by 10; thus 2.14 per cent is the annual rate of increase. By assuming that this rate of growth would continue in the future, population figures can be obtained in any given year. Thus, in this method, the net increment between two years is obtained by applying ‘r’ to the base year population which means the increment remains constant irrespective of the year, and, hence, considered as a crude method of projection.

A slightly improved method is the *compound rate of growth method,* which can be computed with the help of the following formula.

$$R = [(P_n / P_o)^{1/n} - 1] \text{ x } 100 \qquad (2)$$

By the formula

$$P_n = P_o (1+R/100)^n \qquad (3)$$

population in any requisite year can be projected. The value of the expression can be obtained with the help of a scientific calculator by using the function $[Y^X]$ or $[X^Y]$.

$$R = [(1027/846)^{(1/10)} - 1] \times 100$$

$$= [(1.2139)^{0.10} - 1] \times 100$$

$$= [1.0196 - 1] \times 100$$

$$= 1.96\%$$

Thus, during the period 1991 to 2001, population increased at the rate of 1.96 per cent per annum. This rate can now be applied to know the population figures in any given year. For example, population in the year 2011 would be,

$$P_{2011} = P_{2001} \times (1 + R/100)^n$$

$$= 1027 \times (1 + .0196)^{10}$$

$$= 1027 \times 1.2142$$

$$= 1247 \text{ million.}$$

The same method can also be used for projecting other variables like enrolment. One of the limitations of this method is that while computing the rate of growth, it considers information at only two points of time. Thus, it fails to utilize the available statistics fully. There are techniques which consider all the observations in a given set of data. One such technique is the *method of least squares* (which is discussed in a section on enrolment projection). Demographers have adopted this method to project population by assuming that population is a function of a number of independent variables.

The *ratio method* of population projection, which, like the least squares method, considers all the observations, is found to be the most reliable method of population projections at the district level. The ratio method is based on the ratio of the district population to that of the state population. After the ratio of the district to state population is obtained, assumptions are made on the future values of ratios. Once, the future values of ratios are fixed, the population of the district can be obtained by applying that ratio to the projected state population in that year. This can be repeated to any year for which the projected state population is available. In the absence of the projected state population, first the same needs to be projected independently and then only exercise of district level projection can be undertaken. Thus, the ratio (R) is defined as,

$$R = P_i^{[t]}/P_c^{[t]} \qquad (4)$$

where $Pi^{(t)}$ is population of i-th district at time 't' and $Pc^{(t)}$ is the population of the state at time 't' to which district 'i' belongs. The ratio method assumes that population projections in case of the larger area (state), to which the smaller area (district) belongs, is available. Thus, if the district population needs to be projected during the period 2001 to 2021, it is assumed that the state projected population (during 2001 to 2021) is available. In this connection, population projections provided by the Standing Committee of Experts on Population Projections set up by the Planning Commission can be used. The present set of the Standing Committee estimates are likely to change as they are projected by using the population data upto the 1991 Census. The population projections are available state-wise which provide age-specific and single-age population figures separately for the male and female population upto the year 2016.

As an illustration, the computation procedure is presented in Table 1. This can be repeated in any other district for which the state projected population is available. Population in the district is obtained by assuming that the percentage of district population to the state population in 2001 would remain constant throughout the projection period. Population in the age groups 6-11, 11-14 and 6-14 years and single age-6 population at the district and block levels is projected by using the procedure presented above.

Table 1: State and District Population

(Figures in hundreds)

Year	2001	2006	2011	2016
			PROJECTED	
State population	640054 (P_1)	708185 (P_2)	773854 (P_3)	840603 (P_4)
District population	78855	-	-	-
Ratio of district to state population, 2001	0.1232 (X_1)	-	-	-
Projected district population		87248 (P_2 x X_1)	95338 (P_3 x X_1)	103562 (P_4 x X_1)

The above projections are based on the assumption that the share of district to the state population will remain constant. In case the share is available over a period of time, the same can be projected by using the method of least squares. If population projections at the state level are not available, the methodology suggested above cannot be directly applied. In that case, either the state level population needs to be first projected or independent projection exercises at the district level need to be undertaken.

PROJECTIONS BASED ON HOUSEHOLD SURVEY

Population can also be projected by using the single-age population which may be available either through the Census or Household survey. The single-age data in a year is enough to project population in the next six years in case of 6-11, 6-14 and single age-6 population and 11 years in case of 11-14 years population. This can be obtained both at the district and block levels, if the base year single-age population data is available. Thus, if population below age 1, 2, 3, 4………upto age 14 is available in a year, say 2001, then single age-6, 6-11, and 6-14 year population can be obtained annually up to the year 2007 and 11-14 year up to 2012. This can be obtained by assuming that the entire population would grow by one year in the next year and so on. Thus, a child of age 1 now, would be of age 2 the next year and similarly for other ages. However, this does not consider the child mortality rates, which could be considerably higher. This method also does not include migration to other districts. However, if the migration is within the district, it will not affect the outcome. In view of these under reporting, the overall difference in population could hardly be more than 2 to 3 per cent, which may be ignored.

ENROLMENT PROJECTION TECHNIQUES

Enrolment can be projected using either *mathematical or analytical methods*. Mathematical methods require aggregate enrolment data of at least five to ten years, and only total enrolment can be projected by employing both the linear and non-linear equation methods. These methods involve an extrapolation of the past into the future and the assumption that the past trend in enrolment would continue into the future. While in analytical methods, apart from actual enrolment, estimation, assumptions and targets on items like promotion, drop-out, repetition and apparent entry rates are required. The demographic pressures on education can also be captured by the analytical techniques as the computation of the apparent entry rate is based on the population of school entrance age, that is, 6 years. This rate has a significant bearing on enrolment in Grade I, which forms the basis of enrolment in other grades in subsequent years. Thus, an element of judgment in terms of policy variables can be introduced in analytical methods. Targets, assumptions and estimation of transition and entry rates should be feasible and based on the past trend, otherwise, the projection of enrolment would be far from reality.

There are basically three methods of enrolment projections, namely rate of growth, enrolment ratio and grade-transition method. Enrolment can also be projected by using the method of least squares. By taking examples, these methods are explained below.

RATE OF GROWTH METHOD

The simplest technique of enrolment projections is the rate of growth method which requires enrolment data at two points of time. This method assumes a constant rate of increase over the projection period. By this method, one can project aggregate (total) enrolment at different levels of education. However, the method cannot be relied on to make grade-wise projections. The formula for simple rate of growth has already been presented under the section on population projections (equation 1).

Table 2: Rate of Growth Method

Year	Enrolment (Million)	Rate of Growth (%)
1996	55.0	-
1997	60.0	$\frac{(60-55)}{55} x100 = 9\%$
1998	70.0	17%
1999	85.0	21%
2000	105.0	24%
2001	130.0	24%
Projections		**Y = 11.6 + 3.7 X**
2002	$130+\frac{30}{100} x130 = 169.0$	30%
2003	$169+\frac{34}{100} x169 = 226.5$	34%
2004	312.5	38%
2005	440.6	41%
2006	638.9	45%

Let us consider an example. Enrolment for the years 1996 to 2001 is given (Table 2). Simple rate of growth (annual) during 1996- 2001 can be obtained by the formula given above. The next important step is to project growth rates during 2002-2006. For this purpose, the least squares method can be applied. Once these are obtained, calculation of enrolment is an easy task. For example, for the years 2002 and 2006, it can be obtained as follows:

$$E_{2002} = E_{2001} + r_{/100} \times E_{2001}$$

$$E_{2002} = 130.0 + 30_{/100} \times 130.0 = 169.0$$

$$E_{2006} = 440.6 + 45_{/100} \times 440.6 = 638.9$$

Instead, compound rate of growth (equation 2) can also be used, which is expected to yield more realistic estimates than based on simple rate of growth.

ENROLMENT RATIO METHOD

One of the important drawbacks of rate of growth method is that the population factor is completely missing, though enrolment is considered to be a function of population. Also, the projection of enrolment in different grades is not possible. The method which captures demographic pressures also is the enrolment ratio method. It is based on enrolment ratio, which is calculated on the basis of past data, and is extrapolated into the future by applying a suitable mathematical technique or a specific logic. It is assumed that 6-11 years age-group projected population (in case of primary enrolment) is available alongwith the enrolment figures. Results would be more reliable if net enrolment ratio is used instead of gross enrolment ratio. Table 3 illustrates the concept of enrolment ratio method.

The following steps may be followed:

Step I. Population projections (6-11 years) during 2002-06 are required to be worked out, if not readily available.

Step II. Calculate enrolment ratio from 1996 to 2001, say for instance,

$$1996 = 55 / 136 \times 100 = 40\%$$

Table 3: Enrolment Ratio Method of Projections

Year	Enrolment (I-V Classes) (Million)	Population (6-11 years (Million))	Enrolment Ratio (%)
1996	55	136	55/136 * 100 = 40
1997	60	139	60/139 * 100 = 43
1998	70	142	49
1999	85	145	59
2000	105	149	70
2001	130	153	85
Projections		(Given)	
2002	157 x 0.89 = 140	157	89
2003	161 x 0.98 = 158	161	98
2004	165 x 1.07 = 177	165	107
2005	169 x 1.16 = 196	169	116
2006	173 x 1.25 = 216	173	125

Step III. Project enrolment ratios during 2002-06 by method of least squares or by any other suitable method or logical assumptions.

Step IV. Obtain enrolment from 2002-06 by just taking the percentage of enrolment to projected population.

METHOD OF LEAST SQUARES

The other method of enrolment projections (aggregate) is the method of least squares. This method is applicable when time-series data is available. It is a simple method commonly used to make future projections on the basis of the past trend. It is common to fit a straight line to the past observations. Sometime, when the straight line does not represent the past development, we use methods of curve fitting. In order to know the type of relationship the data exhibits, it is always better to try with other curves such as Exponential ($Y = a.\ e^{b.X}$), Logarithmic ($Y = a + b \log X$), Semi-log ($\log Y = a + b.X$), Reciprocal ($1/Y = a + b.X$), Power ($Y = a\ X^{b}$) functions etc. The best equation can be identified on the basis of statistical criterion like mean square error, mean absolute error, coefficient of determination (R^2), standard error of the estimate and significance of the regression coefficients. Here, we shall restrict ourselves to the straight line method popularly known as *'line of the best fit'* or *'method of least squares'*. The fitting of different equations is same as that of the linear equation. The method can be used independently when detailed information is not available.

Total enrolment at the school level from 1997-98 to 2001-02 can be plotted and future enrolment can be obtained. But the limitations of the *graphic method* is that different persons drawing straight lines will get different values of projected enrolment as it is based on the assumption of drawing a straight line which touches a maximum of plotted points. This line (popularly known as regression line) is then extended beyond 2001-02 on the basis of which future enrolment can be worked out. The drawback in using other methods, such as the rate of growth method, is that the projection is based on the growth rate computed between two points which means the rest of the available information is lost. Thus, we should look for a particular method that uses each and every available observation. One such method is the method of least squares (Tables 4, 5 and 6).

Table 4: Given Data

Year	Enrolment (in million)
1997-98	51.99
1998-99	52.49
1999-2000	55.12
2000-01	54.07
2001-02	57.56

A more satisfactory method and a widely used technique is that of estimating the regression line by the technique of least squares. The regression line, which results from the method of least squares, is that straight line which, when drawn through the scatter of points, minimizes the sum of squares of the vertical deviations of the points from the line. The general form of equation for this method is:

$$Y = a + b.X \tag{5}$$

Here, we take 'X' as year, 'a' constant and 'b' slope which give the best-fitting line. To compute the values of the constant of the above equation, the following equations are used:

$$\Sigma Y = Na \quad + b.\ \Sigma X \tag{6}$$

$$\Sigma XY = a.\ \Sigma X + b.\ \Sigma X^2 \tag{7}$$

where:

ΣX = the sum of all observations of X
ΣY = the corresponding sum of all the Y observations
ΣXY = the sum of all the products of X and Y
ΣX^2 = the sum of all the squares of X
N = total number of observations

Table 5 : Enrolment Projections Based on Method of Least Squares

Year	Enrolment (in million) (Y)	S. No. of Col. 1 (X)	Square of 'X'	X.Y
(1)	(2)	(3)	(4)	(5)
1997-98	51.99	1	1	51.99
1998-99	52.46	2	4	104.92
1999-00	55.12	3	9	165.36
2000-01	54.07	4	16	216.23
2001-02	57.56	5	25	287.80
Total	(ΣY) 271.20	(ΣX) 15	(ΣX^2) 55	(ΣXY) 826.35

By using the following two equations, the value of Y = a + b . X can be calculated:

$$\Sigma Y \quad = Na + b\Sigma X \quad = 271.20 = 5a + 15b \tag{8}$$

$$\Sigma XY = a\ \Sigma X + b\ \Sigma X^2 = 826.33 = 15a + 55b \tag{9}$$

Multiply equation (8) by 3 and subtract it from Equation (9) to get the value of 'b'. By putting the value of 'b' in Equation (9), the value of 'a' can also be worked out:

Thus, by interpolation we get the following equation:

$Y = 50.43 + 1.27\ X$ (with 1997-98 as X=1)

In the above example, by putting the values of 'X' we can get values for various years to draw the best-fitting lines and then project it in the future. Accordingly, the enrolment projections for 2002-03 can be worked out as under:

Enrolment in 2002-03 (Y) = 50.43 + 1.27 x 6 = 58.05, **X = 6** in year 2002-03

Similarly, enrolment can be projected in the future by increasing the value of 'X as under:

Table 6: Projected Enrolment

Year	Value of 'X'	Enrolment (in million) (Y)
2002-03	6	58.05
2003-04	7	59.32
2004-05	8	60.59
2005-06	9	61.86
2006-07	10	63.13
2007-08	11	64.40

The methods of rate of growth, enrolment ratio and least square cannot be considered as ideal methods of enrolment projection as they do not take into account the internal dynamics of enrolment from year to year and from one grade to another. The most suitable and scientific technique of grade-wise enrolment projection is based on the student-flow model. Two methods namely, Grade-Ratio and Grade-Transition methods are available for grade-wise enrolment projections.

GRADE-RATIO METHOD

Grade-ratio method is used when data on repeaters is not available and grade-wise enrolment projections are required.

Data Requirements

The method requires the following set of data:

- Enrolment and number of repeaters for at least two consecutive years;
- School entrance age population (generally age ‘6’) for over two consecutive years;
- The number of graduates in each year for the final grade (say grade 6, 9, etc.); and
- Targets on certain items such as promotion, repetition, drop-out rates and admission rate.

These rates and targets should be flexible so that enrolment projections are reliable. If the data on repeaters is not available, then projected enrolment would not be totally reliable. In the grade-ratio method, grade ratios for different grades over a period of time are calculated by taking the percentage of enrolment in the next grade in the next year to the enrolment of the previous year in the previous grade. In notation,

$$GradeRatio = \frac{E_{g+1}^{t+1}}{E_{g}^{t}} x100 \qquad (10)$$

where ‘E’ is Enrolment, ‘t’ = Year and ‘g’ = Grade.

The different steps of grade ratio method are as follows (Table 7):

Step I. Put the grade-wise enrolment (I-V Grades) and population of age-6 in the appropriate boxes. For the projection period, if population is not available, project it by a suitable demographic technique or the projections made available by other agencies should be considered.

Step II. Calculate gross apparent entry rates for all years and project these rates upto 2007 with the help of any suitable mathematical method or least squares method. The equation will work out as Y= 24.00 +0.99 X with ‘X’ in 1998 as 1 and in 2002 as 5.

Step III. Calculate the ratio of enrolment in the next higher grade in the next year to the enrolment to the previous grade in the previous year for all the grades. (For example, grade-ratios for some of the classes have been worked out as under):

$$1998 \text{ to } 1999 \text{ Class I to II} = \frac{38}{50} x100 = 76\%$$

$$\text{Class III to IV} = \frac{21}{24} x100 = 88\%$$

$$2001 \text{ to } 2002 \text{ Class II to III} = \frac{37}{45} x100 = 82\%$$

$$\text{Class IV to V} = \frac{26}{27} x100 = 96\%$$

Project ratios upto 2007 by a suitable mathematical method, or they can be fixed keeping in view the available policy options.

Step IV. Calculate enrolment in Grade I from 2003 to 2007, by multiplying the entry rates already projected to projected age-6 population:

$$2003 = \frac{228x22.9}{100} = 68, \qquad 2006 = \frac{247x32.9}{100} = 81$$

Step V. Calculate enrolment of other grades on the basis of projected grade ratios from one grade to another:

$$\text{i.e. } 2003 = \text{Class II} = \frac{64x81}{100} = 52$$

$$\text{Class V} = \frac{30x97}{100} = 29$$

$$2007 = \text{Class III} = \frac{65x87}{100} = 56$$

$$\text{Class IV} = \frac{51x96}{100} = 49$$

Step VI. Enrolment for the primary stage can be obtained by adding enrolment in I to V classes, which can be used to compute projected enrolment ratios.

GRADE-TRANSITION METHOD

The grade promotion method is a simplified approach for enrolment projections and should be followed only when data on repeaters is not available. It is to be noted here that in Grade I, we assume that enrolment in this class is entirely a function of the population of 6-year old children, but the fact is that a large number of repeaters remain in this grade. This method is not suitable for analyzing implications of changes in educational policy, since the most important parameters depending upon educational policy like promotion, repetition and drop-out rates are not taken into account in this method. For which, grade transition method may be appropriate, which considers the number of repeaters and other indicators.

The calculation procedure of the grade transition method slightly differs from the grade ratio method (Table 8). Net Entry Rate is used in place of apparent entry rate and grade-wise enrolment is obtained by assigning the promotion, repetition and drop-out rates in different grades and years in place of grade-ratios only. The planner can easily identify how a separate change in any one of these factors will affect the future enrolment and output. Different combinations of the values of flow-rates will yield a number of possible outcomes; by taking any set of assumptions, the effects on enrolment and output can be calculated easily; and a particular set of enrolment can be retained for planning purposes. The following steps should be followed:

Step I. Obtain single age-6 population during 1998 to 2002 for which grade-specific enrolment in Grades I to V is available. Also project the same during the period 2003 to 2007 for which enrolment is required to project. Methods explained above may be used for this purpose.

Step II. Calculate new entrants/fresh admissions in Grade I during the period 1998 to 2002 by subtracting repeaters from enrolment. For example, enrolment in Grade I in 1999 was 53 and the number of repeaters 14, so the new entrants would be 39 i.e. (53-39). Similarly, new entrants in other years are calculated.

Step III. Calculate the net apparent entry rate for the period 1998 to 2002 by dividing new entrants in a year by the single age-6 population. For example, in

2001, total new entrants are 46 and singe age-6 population 216, so the entry rate would be

$$\frac{[61-15]}{[216]}x100 = 21.30\%$$

Similarly, entry rate in other years are calculated.

Step IV. Project net apparent entry rate for the period 2003 to 2007. This can be done in the following ways: (a) by assuming that the entry rate in the latest year will remain constant throughout the period 2003 to 2007; (b) by applying suitable statistical methods like method of least squares; and (c) by using the policy options. If the policy is to achieve UPE by 2007, the targeted entry rate is adopted accordingly (100 plus the percentage of overage and underage children in Grade I). In the present example, entry rate is projected by applying the method of least squares (Y = 17.5 + 0.9 X, with 'X' in 1998 as 1 and 2003 as 6).

Step V. Now, calculate the number of new entrants during the period 2003 to 2007 by multiplying the projected entry rates with single age-6 population. For example, new entrants in 2003 is obtained as:

$$(228) \text{ x } \frac{22.8}{100} = 52$$

Step VI. With the help of enrolment and number of repeaters, first obtain the number of promotees in each grade during the given period 1998 to 2002. By using the number of repeaters and promotees, obtain repetition and promotion rate for each grade during 1998 to 2002.

Step VII. Based on the actual promotion and repetition rates, project the same for the period 2003 to 2007. This can be done either by capturing trends or by applying policy options. In case of no detention policy, the values should be adopted accordingly.

Step VIII. Now, calculate the number of repeaters in Grade I and add the same to the number of new entrants to obtain enrolment in Grade I. This should be repeated to obtain enrolment in Grade I for the entire period 2003 to 2007. For example, the number of repeaters in 2003 is 16 and that of new entrants is 52. Enrolment in Grade I would, therefore, be 68. The number of repeaters in 2004 would be 17 i.e. (68 x 25)/100, which is then added to number of new entrants (56) to obtain enrolment (73) in Grade I, the following year, i.e. 2004.

Step IX. With the help of projected promotion rate and Grade I enrolment, calculate the number of promotees during the period 2003 to 2007. Add the number of repeaters to the number of promotees to obtain Grade II enrolment. By following the same procedure, enrolment in different grades during the entire period 2003 to 2007 should be obtained.

Step X. The projected grade-specific enrolment should now be added together to obtain total enrolment in primary grades during the period 2003 to 2007.

Step XI. Compare the projected enrolment in primary classes with the projected population of 6-11 years to obtain enrolment ratio during 2003 to 2007.

Step XII. With the help of the projected Grade V and Grade I enrolment, calculate the retention rate for the entire period of projections.

Step XIII. By assuming different values of entry, repetition and promotion rates, repeat the exercise and generate alternative scenarios and retain the one, which is best suitable to the district. The targeted GER and Retention rate should be adopted by following the above procedure only.

Step IX. Repeat the exercise separately for boys and girls enrolment.

PROJECTIONS OF UPPER PRIMARY ENROLMENT

Upper primary enrolment can be projected in a variety of ways. The traditional methods presented above can also be used to project upper primary enrolment. Depending upon the requirements and availability of data, aggregate or grade-specific enrolment may be projected by using the mathematical or analytical methods. The limitations of mathematical methods hold true for the upper primary level as well. However, *Grade-Transition method remains* the most reliable method. In addition, upper primary enrolment can also be projected by considering the following four alternatives:

I. Based on Ratio of Upper Primary to Primary Enrolment;
II. In relation to Grade V Enrolment as a Percentage of Total Primary Enrolment;
III. In Terms of Graduation and Transition Rates; and
IV. In Terms of Retention Rate and Grade I Projected Enrolment

— BASED ON RATIO OF UPPER PRIMARY TO PRIMARY ENROLMENT

Enrolment in upper primary classes can also be projected by using the ratio of upper primary to primary enrolment. The ratio can be calculated by considering the total enrolment in primary and upper primary classes in the latest year. This ratio is then applied to independently projected enrolment in primary classes to obtain upper primary enrolment in different years. Though the alternative is simple to apply but it cannot be used to project grade-specific enrolment. The other limitation is that it assumes ratio of upper primary to primary enrolment to remain constant which may not remain valid in years that follow. However, it is enrolment of Grade V, in particular, rather than the total primary enrolment from where the student' transit to first grade of the upper primary cycle. Further, no method is expected to produce reliable estimates of enrolment unless the corresponding age-specific population is considered in projection. Lastly, the alternative assumes that the projected primary enrolment is available which may not always be true. Therefore, the alternative should be applied only when quick estimates of the total enrolment in upper primary classes is required.

— IN RELATION TO GRADE V ENROLMENT AS A PERCENTAGE OF TOTAL PRIMARY ENROLMENT

Alternatively, enrolment in upper primary classes can also be projected in terms of percentage share of Grade V enrolment to the total primary enrolment. The ratio should first be calculated for the latest available year, which, in turn, should be adjusted for the drop-out rate. Enrolment in Grade V can now be obtained in two ways, namely: (a) by using the projected primary enrolment; and (b) by using population of age group 6-11 years by considering them as potential enrolment in primary classes. In case the age group population 6-11 years is used, the same should be adjusted in the light of the drop-out rate and the percentage of over-age and under-age children in primary classes. By applying the adjusted ratio of Grade V to the projected/potential primary enrolment, enrolment in Grade V is obtained for different years. The projected Grade V enrolment along with the transition rate from Grade V to VI is then used to project Grade VI enrolment which, in turn, is multiplied by three to obtain the total enrolment in primary classes.

This alternative, too, is not free from limitations as it also demands for the projected enrolment in primary classes. The other significant limitation is in its consideration of ratio of Grade V to the total primary enrolment itself. Enrolment in the primary classes consists of Grades I to V all of them being members of the different cohorts. Some of them entered in the system one-year back; others entered two or more years back. Therefore, it is not logically correct to calculate ratio of Grade V to the total primary enrolment. No method based on Grade V enrolment is expected to produce reliable estimates of the upper primary enrolment, unless enrolment in Grade V is linked to the original enrolment in Grade I.

— IN TERMS OF GRADUATION & TRANSITION RATES

It may be noted that enrolment in the upper primary classes is not only a function of the age-specific population i.e. 11-14 years but also a function of the primary school graduates. Only primary graduates can be enrolled in the first grade of the upper primary level of education. However, all those who complete primary level do not transit to the upper primary level but a few of them also dropout from the system in transition. Therefore, methods independent of the graduation and transition rates are not expected to produce reliable estimates of upper primary enrolment.

How to compute graduation and transition rates and what are the data requirements is an important question. Graduation rates are calculated at the end of an educational level, i.e. Grade V and Grade VIII, whereas transition rate is calculated between two educational levels, i.e. Grade V, the last grade of primary level and Grade VI, the first grade of upper primary level. The following set of information is required to compute the graduation and transition rates:

- Numbers of students (enrolment) reaching Grade V;
- Number of repeaters in Grade V;
- Number of students (graduates) successfully completing Grade V;
- Number of graduates (successful completers of Grade V) taking admission in Grade VI, the first grade of the next education level;
- Number of students (enrolment) in Grade VI along with number of repeaters; and
- Enrolment in Grade I of the original cohort (four years back) through which the graduates have entered into the system.

It may be noticed that the requisite sets of data needed in the calculation of graduation and transition rates are generally not fully available. Of the above information, only enrolment and repeaters are available. Even the number of successful primary school completers is not available. Hence, it is not possible to calculate the true graduation rate. At the most, the number of successful completers (graduates) can be linked to the enrolment in Grade I in the original cohort to obtain the graduation rate. This rate is termed crude because repeaters are also included in the graduates. Some primary graduates would have taken five years to complete primary level; others would have taken more than five years. From the available data, it is not possible to know the distribution of graduates according to number of years taken to become graduates. The only way to obtain the true graduation rate is to keep a track of each and every member of the cohort till the last member remains in the system.

Since the number of graduates is not available, alternatively enrolment in Grade V can be considered along with the transition rate from primary to upper primary level to project upper primary enrolment. Enrolment in Grade VI in a year excluding repeaters is divided by the enrolment in Grade V, the previous year, to obtain the transition rate. This rate is then applied to the projected Grade V enrolment to obtain Grade VI enrolment assuming that the transition rate will remain constant in years that follow. Similarly, enrolment in Grades VII and VIII can also be obtained by applying the transition rates from Grades VI to VII and Grades VII to VIII to the enrolment in Grades VI and Grade VII. This should be done separately for boys and girls, which, in turn, is added together to obtain total enrolment in upper primary classes (Grades VI-VIII). The following steps should be followed (Table 10):

I. Project Grade V enrolment over a period of time by using Grade Ratio or Grade Transition Method
II. Calculate Transition rate from primary (Grade V) to upper primary level (Grade VI)
III. Apply Transition rate (Step II) to the projected Grade V enrolment (Step I) to obtain Grade VI enrolment over a period of time
IV. Calculate Transition Rate from Grade VI to Grade VII and Grade VII to Grade VIII
V. Apply Transition Rate from Grade VI to Grade VII and Grade VII to Grade VIII (Step IV) to the projected Grade VI enrolment (Step III) to obtain Grade VII and Grade VIII enrolment
VI. Add enrolment in Grade VI, Grade VII and Grade VIII to obtain total enrolment in Grades VI-VIII
VII. Repeat Steps I to VI separately for boys and girls and by adding together obtain total enrolment in Grade VI, Grade VII and Grade VIII over time.

Table10 : Enrolment and Repeaters

(in thousands)

	Grade V	Grade VI	Grade VII	Grade VIII
Enrolment 2000-01	17991	16072	14172	12572
2001-02	18026	17105	14673	13072
Repeaters 2000-01	202	197	167	159
2001-02	199	167	170	165
Year	**2002-03**	**2003-04**	**2004-05**	**2005-06**
Projected Grade V Enrolment	18890	19101	19567	19999

Transition Rate for 2000-01 can be calculated as follows:

$$= \frac{\text{Grade VI enrolment in 2001-02 excluding number of repeaters}}{\text{Grade V enrolment in 2000-01}} \text{ x } 100$$

$$= \frac{(17105 - 167)}{(17991} x100 = \frac{16938}{17991} x100 = 94.15\%$$

This rate (94.15 per cent) is then applied to the projected Grade V enrolment in 2001-02 (Table 10) to obtain Grade VI enrolment.

Grade VI Enrolment, 2002-03 = $\frac{18026x94.15}{100} x16971$

Similarly, Grade VI enrolment in the remaining years is also obtained. The next important task is to project Grade VII and VIII enrolment. For this purpose, first transition rates from Grade VI to VII and Grade VII to VIII need to be calculated in the following manner:

Transition Rate Grade VI to VII, 2000-01 = $\frac{\text{Enrolment in Grade VII in 2001-02 excluding Repeaters}}{\text{Enrolment in Grade VI in 2000-01}}$

$$= \frac{14673 - 170}{16072} = 90.24\%$$

$$\text{Transition Rate Grade VII to VIII, 2000-01} = \frac{\text{Enrolment in Grade VIII in 2001-02 excluding Repeaters}}{\text{Enrolment in Grade VII in 2000-01}}$$

$$= \frac{13072 - 165}{14172} = 91.07\%$$

The transition rates are then applied to the projected Grade VI enrolment. For example, the projected enrolment in Grade VI in 2002-03 is 16,971 thousand, of which 90.24 per cent children will transit to the Grade VII next year. The projected enrolment of Grade VII in 2003-04, thus, would be 15,315. Similarly, projections of Grade VIII can also be obtained.

— IN TERMS OF RETENTION RATE AND GRADE I PROJECTED ENROLMENT

In the third alternative, Grade V enrolment is projected by using the analytical techniques. Grade V enrolment can also be projected on the basis of retention rate. Enrolment in Grade V (minus repeaters) is linked to the enrolment in Grade I (original cohort) and retention rate is obtained. For example, if the latest Grade V enrolment is available for 2000-01, Grade I enrolment in 1996-97 is used in computing the retention rate. The retention rate is then applied to the projected enrolment in Grade I to obtain Grade V enrolment. The projected enrolment in Grade V is then used with the transition rate (follow Steps II to VIII above) to project enrolment in upper primary classes.

The difference between the present and the previous alternatives is in its consideration of the projected Grade I and Grade V enrolment. If the projected enrolment in Grade I is not available, the same needs first to be projected by employing the analytical methods discussed above. The basic set of Grade I enrolment may be either gross or net in nature. Care should be taken to subtract repeaters from the Grade V enrolment while computing retention rate. If the Grade I enrolment is gross in nature, the corresponding enrolment of Grade V should also be gross in nature. This method is useful in developing alternative scenarios. It assumes that the present level of retention will remain constant in years that follow, which may not remain valid in the long term. The alternative provides flexibility to the user to consider different values of retention rate and see its implications on enrolment in the upper primary classes. The retention rate as well as enrolment in Grade I in future can also be linked to the policy options. If the target is to achieve the universal retention by 2007, then while projecting

Grade V enrolment, retention rate of 90 or 100 per cent can be assumed. Similarly, if the target is to achieve the UPE by 2007, all children of age-6 would be required to enroll by 2003. In this case, enrolment in Grade I in 2003 would be equivalent to the total population of age-6 plus adjustment on account of the over-age and under-age children (entry rate). Thus, by considering different values of the entry, retention and transition rates, enrolment in the upper primary classes can be projected.

For example, if enrolment in Grade V in 2001-02 is 18,026 thousand, repeaters 199 thousand and enrolment of Grade I in 1997-98 is 32,895 thousand, then retention rate would be [(18,026 –199)/(32,895)] x 100 i.e. 54.19 per cent. Using this rate and enrolment in Grade I, enrolment of Grade V can now be projected. For projecting Grade V enrolment in 2002-03, enrolment of Grade I in 1998-99 is required. If enrolment in Grade I in 1998-99 is 33,576 thousand, then enrolment of Grade V in 2002-03 would simply be 54.19 per cent of the 33,576 thousand i.e.18,194 thousand. Transition rate should now be applied to the projected Grade V enrolment to obtain Grade VI enrolment. Similarly, enrolment in Grade VII and Grade VIII can also be projected.

PROJECTIONS OF TEACHERS

Enrolment statistics forms the basis for many investment decisions in education. A teacher is the most important academic input especially at the primary level and teacher's salaries accounts for a major share of recurring expenditure on education. Projections on requirements of teachers follow enrolment projections. The most commonly used methods of teacher projections are:

(i) Pupil-Teacher Ratio; and

(ii) Method based on the number of pupils per class and hours taught by a teacher.

Pupil-Teacher Ratio Method

The simplest method of teacher projections is known as the pupil-teacher ratio method. It is a very simple calculation based on the pupil-teacher ratio formula:

$$T_s^t = \frac{E_s^t}{R_s^t} \tag{11}$$

where,

T_s^t = Number of teachers at a particular time (t) and for particular stage or school (s);

E_s^t = Enrolment at particular time (t) for particular stage or school (s); and

R_s^t = Teacher-Pupil Ratio at a particular time (t) for particular stage or school (s).

The distinction between stage and school needs to be carefully noted. For stage-wise enrolment, stage-wise teachers are required for calculating teacher-pupil ratio. This method, though very simple, is suitable for making projections mainly at the primary stage of education where specialized teaching is not a norm. . For other stages of education, this method is not suitable. However, it needs to be noted that one of the basic assumptions of this method is that it is the number of students and not their grade distribution which is important. This assumption is not valid in India, especially in the remote rural areas because of multi-grade teaching. However, in the post-compulsory levels of education, subject specialization is important and hence, this method is not a suitable one.

Method Based on Number of Pupil per Class and Hours Taught by Teacher

This is technically a better method of making projections of teacher-requirements in the future, as it takes into account the following variables:

I. Size of the class;
II. Number of hours the students receive instruction per week; and
III. Number of hours taught by a teacher per week.

The following set of data is required which may or may not be available at different levels (block/district/state), but may be available at the institutional level.

- Stage-wise enrolment;
- Average number of hours per week for a student as per time-table;
- Average number of students taught at the same time by one teacher; and
- Average number of student-hours per week taught by a teacher.

According to this method, the requirement of teachers is determined by the following procedure:

$$T = \frac{ExH_s}{RxH_t} \tag{12}$$

where,

T = Number of teacher required;
E = Projected enrolment;
R = Average number of students per teacher or per instructional group or size of average class;
H_S = Average number of weekly hours per student which is generally prescribed in the school curricula; and
H_t = Average number of weekly hours per full-time teacher.

Equation (12) is very useful for planning purposes. All the different factors can be planned, as none of them is constant. In this equation, the number of teachers required is directly proportional to the number of pupils and the average weekly hours per student. If the number of hours taught per week by the teacher is equal to the number of hours of teaching required by the students, the equation will become simple and identical to the first method:

$$\mathrm{T} = \frac{E}{R}$$

In case, the authorities decide the teacher-pupil ratio or the same is prescribed as a norm, then the method presented above may not be used to work out the number of teachers. Naturally, the educational administrator will consider certain factors, such as the immediate past trend in teacher-pupil ratio, logic for increased or reduced ratio, their financial implications and availability of funds.

Tables 10 and 11 demonstrate the use of both these methods. To begin with, the base year ratio is computed, and on the basis of resources available, the pupil-teacher ratio is projected or fixed in the future. Fixing of weekly hours per teacher (better to use state norms) is a policy decision and should be carefully assumed. While taking into account the total additional requirement of teachers, one should take into account the rate of replacement of teachers. The steps for projecting requirements of teachers can be divided into two parts:

(i) Calculating the total number of teachers required; and
(ii) Calculating the net additional teachers required during the year.

The following assumptions have been made in the above calculations:

- Teacher-pupil ratio will be gradually increased from 23 in 2002 to 25 in year 2007;

- Weekly hours per student will remain the same; and

- Weekly hours per teacher will be gradually increased from 20 hours in 2002 to 22 hours in 2007.

Table 11 : Projection of Teachers

Year	Enrolment Projections (E)	T:P Ratio (R)	Weekly Hrs./ Student (Hs)	Weekly Hrs./ Teacher (Ht)	Teachers Required (T)
2002	22,000	23.0	36.5	20.0	1,746
2003	28,000	23.4	36.5	20.4	2,141
2004	34,000	23.8	36.5	20.8	2,544
2005	40,000	24.2	36.5	21.2	2,846
2006	47,000	24.6	36.5	21.6	3,229
2007	54,000	25.0	36.5	22.0	3,584

The next step is to obtain the net additional requirement of teachers, which can be worked out by considering the annual replacement of teachers on account of attrition like retirement, death, resignation etc., on the part of the teachers. This rate has been assumed in the present exercise to be 2 per cent but varies in different cases. The net total requirement of additional teachers can be used as a basis for fixing the intake of teacher-training institutions and also to work out the subject-wise requirement of teachers.

As mentioned earlier, the pupil-teacher ratio method is the easiest method for projecting teachers at the primary level. However, using this method may imply that many schools in the remote rural areas may remain single-teacher schools since the size of the enrolment is very small. After the National Policy on Education, 1986, the government has adopted a policy of providing a minimum of two teachers for every primary school. Such a norm limits the application of the pupil-teacher method to estimate teacher requirements. In the context of decentralized planning, teacher requirements are to be estimated on a school-to-school basis. As a first step, each school should be ensured of two teachers. Enrolment in the school is not the basis for estimating the basic minimum teacher requirement. A third teacher can be provided to the school, based on the enrolment projections exceeding a specified limit. For example, let us assume that the existing pupil-teacher ratio in a state is 1:40. The small schools will be provided with two teachers irrespective of enrolments. However, a third teacher may be provided only if enrolment exceeds 80. This requires estimations of teacher requirements on a school-to-school basis.

Table 12 : Net Additional Requirement of Teachers

Year	Total Requirement of Teachers	Additional Requirement of Teachers	Additional Teachers on Account of Attrition (@ 2%)	Net Additional Teachers Required
1995	1746	- (2141 – 1746)	-	-
1996	2141	395	43	438
1997	2544	403	51	454
1998	2846	302	57	359
1999	3229	383	65	448
2000	3584	355	72	427

SETTING-UP OF TARGETS: POINT OF CAUTION

The projection techniques presented above can be of grate help in fixing targets on enrolment, retention and teachers. As mention above, it would help planner in setting out realistic targets. Definitely the outcome of the diagnosis exercise would play decisive role in adopting targets on enrolment and other transition rates. Needless to mention that targets should be based upon the immediate past trends and they should be realistic one and should always be based upon the present status of educational development in the district.

Depending upon the availability of data on repeaters, grade-ratio or grade-transition method is applied. In the first exercise, assuming that all the rates/indicators would remain constant in years that follow, grade-specific enrolment should be projected. Once the total enrolment at the primary level in different years is projected, the next step is to project the GER and Retention Rate in different year. The projected GER and Retention Rate would indicate the likely values based upon the assumption that no improvement would take place and the existing values of entry, dropout, promotion and repetition rates would remain constant in years that follow. This exercise would indicate whether at present rates, the goal of UPE in the district is achievable, if yes then by which year. In case, if it indicate that the goal is not likely to be achieved in the near future; thus meaning that without improving the existing rates, the goal will not be achieved.

Let us suppose that the objective of a particular programme is to achieve the goal of UPE by 2007 and the projected GER comes out to be only 70 per cent, it means that without improving the existing rates, the goal of UPE cannot be achieved. While analyzing the outcome of the projections, due attention should be given to overage and underage children, if enrolment that you deal with is gross in nature. Thus, if the percentage of overage and underage children is 22 per cent, the targeted GER would be 122 per cent and not 100 per cent. Needless to mention that the percentage of overage and underage children and also the targeted GER to achieve UPE would vary from district to district and also from block to block within the district. Similarly, one has to critically analyze the projected retention rates so as to ascertain whether it would be possible for the district to achieve the goal of UPE by 2007. The projected enrolment of Grade V in a year, say 2007 be linked to enrolment in Grade I, four years back, say 2003 to find out projected retention rate at the end of the primary level. This should also be projected block-wise and separately in case of boys and girls. The other key indicator that would be of significance in adopting the target is entry rate, which should also be analyzed both at the block and district level. While adopting the target on the entry rate, overage and underage '6' children should also be considered, if enrolment data is gross in nature. The necessary condition of achieving UPE is that all children of age-6 are enrolled; thus by meaning that net entry rate is hundred. The targeted entry rate should be realistic, achievable and should also be based upon its present value.

At the existing level of entry and other rates, if it is not possible for the district to achieve the goal by 2007 would indicate improvement in years that follow. Therefore as an alternative to the above, in the second exercise by taking different values of entry rate and grade-specific promotion, dropout and repetition rates, the projected GER and Retention Rates are obtained. The one, which is best suitable (achievable & realistic one) to the district, can be retained. While retaining the future rates, the existing rate should be considered to know whether it would be possible for the district to achieve it in a short span of 4 to 5 years. If the rate that you think required to achieve UPE is not realistic, don't adopt it. Past trends in this regards would be helpful. Let us suppose that you retain a GER of 110 per cent (including overage & underage children) from the existing 70 per cent and Retention Rate of 90 per cent from the existing 60 per cent meaning that you expect a lot of improvement from the existing levels in the years that follow. This would not be achieved automatically. District-specific strategies would have to be adopted to improve upon the existing levels of all these rates. The targeted rates as well as the strategies to achieve them would vary from district to district and also from block to block. One individual member of the planning team should not adopt the strategies. All those who are interested in the development of the primary education in the district should be consulted. Proper identification of problems during the diagnosis should be supplemented by the focus group discussions, as it will be of great help in this regard.

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