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Integrated Approach to Human Resource Forecasting: An Exercise in Agricultural Sector

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Abstract

This paper has described methodological framework for human resource forecasting in agriculture, especially for transforming human resource needs to educational requirements. It has provided a detailed description of methodological adaptations applied to human resource assessment in Indian agriculture. It has offered a mixed method with a brief revisit to classical Parnes manpower requirements approach and its adaptation to Indian agriculture. The method is perhaps suitable to many developing countries, where data needed for applications of more sophisticated forecasting methods adopted in the developed countries have limitations in terms of quality and quantity.

Key words: Manpower forecasting, human capital assessment, human resource planning, mixed method forecasting; manpower supply & demand

JEL Classification: Q11

Introduction

Human resource forecasting is a critical element in the process of human resource planning, both at the micro (enterprise, etc.) and macro (regional, national, industrial, etc.) levels. The forecasts of human resource demand and supply not only provide insight into the right quantity and quality of the human resources required to maintain the desired growth of a sector but also help in planning educational curricula commensurate with the labour market needs.

Manpower planning, at various levels of sophistication, has been integral to the economic development plans in most developed countries for over half a century, while in developing countries, the subject has started gaining interest and attention in the past few decades (Willems, 1996; Ozay Mehmet, 1977; Psacharopoulos, 1984; 1991). In the developing countries, there is a strong urge to match the skills required with the skills available, and put efforts in human resource development leading to optimum utilization and wastages minimization (World Bank, 2006).

The emergence of interest in human resource planning has led to methodological advances as well as debates about the relevance and efficacies of alternative methodologies under various conditions (Willems, 1996). This paper elaborates some of the commonly practised techniques in human resource forecasting and their applicability in various situations, especially under data constraints in developing countries. The paper surveys methods adopted in various countries and provides an overview on the history of manpower planning in India from a methodological perspective. It concludes with a recent exercise in human resource forecasting in the agricultural sector in India as example and recommends a suitable model for human resource forecasting under

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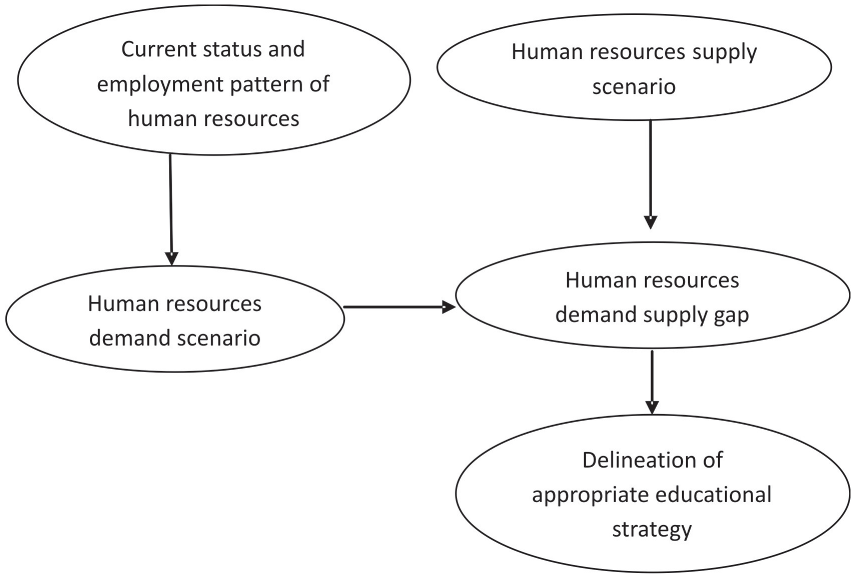

Figure 1. Essentials of human resources demand and supply processes – A schematic diagram

Indian conditions, which can be replicated in other developing countries with adaptations.

Conceptual Overview

Human Resources Supply-Demand Process

Human resources demand and supply can be viewed in terms of both flows as well as stocks. When considered in terms of flows, these terms imply net additional demand and supply during some period, say a year. In terms of stocks, they imply the total quantum of human resources deployed and the total stock of economically-active human resources available at a particular point of time. A graphical representation incorporating the essentials of human resources demand and supply processes is shown in the Figure 1, which presents the manner in which analysis of supply and demand data would lead to educational strategy.

Forecasting Approaches in Practice

Over the past half century, a variety of techniques for human resources forecasting have been employed in different countries and under different situations of data availability. Some of the widely used approaches are:

Employers' Survey — It is a straight-forward method of ascertaining the anticipated needs of human resources over the forecast period directly from the employing agencies.

Norm-based Forecasts — This method uses the ratios between human capital and tasks, as a norm for estimating the required human resources. These ratios are based on either the existing situation or the desirable situation (IAMR, 1979; Rowat, 1983; Nichakorn *et al*., 1998).

Time-series and Regression Models — Time-series models forecast the human resources requirement on the basis of trend, i.e. the historical pattern of changes (Bartholomew and Forbes, 1979). The regression models establish the relationships between human resources and other associated predictable variables (Lee Hong and Chen, 2001; Susiganeshkumar and Elangovan, 2010).

Econometric Model — The econometric models postulate the interplay of a number of variables through a set of structural equations that have been developed for forecasting human resources (Psacharopoulos, 1973). Some of the extensively used econometric models are Timbergen-Jos model (Timbergen and Correa, 1962), and BACHUE models[1] developed by ILO during the 1970s.

[1] The BACHUE models were developed under ILO's World Employment Programme for the Philippines, Kenya, Brazil and Yugoslavia

Mathematical Models — These models include Markov models, Simulation models, and System Dynamic models. Markov chain models extensively use the concept of transition probability matrix. On this, various tools have been developed over time for forecasting (Trivedi *et al*., 1987; Raghavendra, 1991; Škulj *et al*., 2008). The simulation and system dynamics (SD) models determine the requirements by imitating the system (Deane and Yett, 1979; Song and Rathwell, 1994; Mondal *et al*., 1992; Shivanagaraju *et al*., 1998; Mohapatra *et al*., 1990).

Rate of Returns Approach — In this approach, the rates of return to investments in different streams of education are computed by assessing the life-time earnings for different streams.

Manpower Requirements Approach (Parnes Model) — The model propounded by Parnes (1962) in the context of Mediterranean Regional Project (MRP) during the early-1960s was designed to forecast manpower requirements by occupation and then by educational categories so that the forecasts could be rendered directly relevant to educational planning exercises.

Qualitative Forecasts — The qualitative methods such as Delphi, Focus Group Discussions, and Nominal Group Technique, etc. are also applied to forecasting through qualitative data (Kerr and Tindale, 2011).

Notwithstanding their limitations, these approaches are used independently or in combination to develop occupational forecasts on a fairly regular basis. In India, the exercise of human resource planning started in 1946 with forecasting of the number of medical professionals required in the next 25 years. Since then the forecasting exercise has been extended to cover a wide range of professionals such as engineers, scientists, managers, information technology personnel, etc., and economic sectors like agriculture, health service, manufacturing industries, etc. (ESCAP, 1999; AFF, 2000; TCS, 2000, IAMR, 2001, Rama Rao *et al*., 2005; NSDC, 2011;). The forecasting approaches followed in some of these exercises have been summarized in Table 1. In most of these studies, the projections were made following norm-based or trend approach. However, with the advent of advanced computing facilities, modelling approaches were adopted.

Methodology

Methodological Issues and Constraints

Severe constraints in applying various sophisticated methods of forecasting in developing countries like India are the data availability and its quality. Either the data are not available at all, or in requisite details or with sufficient frequency that enables establishment of trends. The authenticity of available data is often open to question. Difficulty in reconciliation of data on the same variables from different sources is yet another difficult issue.

Over the years, India has evolved an elaborate statistical system in the field of employment and manpower. The decennial population censuses provide the basic benchmark data on available workforce in various economic sectors and its characteristics. The National Sample Survey Office's five-yearly labour force surveys generate substantial data on employment and unemployment using a variety of concepts relevant to a predominantly unorganized labour force. Data from these two sources enable the planners to the project the total labour force reasonably well over the medium-term (Five-Year Plan periods). However, data on sectoral occupational and educational patterns with the desired degree of disaggregation and precision that enables the assessment of current occupational/ educational profile in various sectors are not available.

Some data on educational and occupational profiles of employment in various segments of the organized sector (comprising all public sector establishments and the larger establishments in the private sector) are collected by the Ministry of Labour, Government of India, once in two years. Such data were indeed used to develop manpower forecasting using Parnes's approach in the late-1960s. However, the system of data collection and analysis has become so cumbersome that the analysis and dissemination of such data have in due course become highly discontinuous, and are not available for about a decade now.

There are elaborate data collection systems for several individual sub-sectors such as educational services, health services, small-scale industries, etc., each of which has its own content, but often with inadequate attention to human resource aspects. In view of this, the human resource forecaster is generally left with no alternative but to make with bits and pieces of

Table 1. Approaches for human capital forecasting in India

Year	Sector forecast	Method	Reference
1946	Medical manpower over a 25-year period (Health Service and Development Bhore Committee-1946)	Normative	Cited from GOI, 1997
1947	Scientific and technical manpower in public and large private sectors (Scientific Manpower Committee-1947)	Normative ratios between production target and manpower requirement	Virendra Kumar, 1976
1957	Agricultural personnel requirement (Agricultural Personnel Committee-1957)	Survey	Cited from Brand, 1960
1959	Technical personnel requirement for third (1961-66) and fourth five-year (1966-71) plans	Direct enquiry for medium-term & analytical approaches for long- term	Cited from Verma, 1985
1966	Manpower demand estimate (Education Commission of GOI, 1964-66)	Normative and growth rate	Cited from Verma, 1985
1967	Occupational manpower requirements over the period 1968-69 to 1978-79	Parnes approach	DGE&T, 1967
1999	Human requirement in tourism sector in India	Norm based	ESCAP,1999
2000	Agricultural manpower requirement in Haryana	Norm based	AFF, 2000
2000	Manpower needs of the agricultural sector in Tamil Nadu	Co-efficient based model	TCS, 2000
2001	Manpower needs in agriculture and allied sector	Norm based and growth trend	IAMR, 2001
2004	Trained agricultural manpower requirement in India	Mixed approach and system dynamics modelling	Rama Rao *et al*., 2011
2010	Food sector	Norm based, macro-economic modelling	NSDC, 2010

information available from various sources and/or undertake own survey of the labour market relevant to the industry/ human resource group of interest.

Apart from quantitative data, a number of other qualitative factors influence the forecast analysis. These factors relate to the frequently-changing labour market indicators which can be captured only through interaction with various stakeholders.

Mixed Methodology

The limitations of availability of quality data pose methodological constraints in application of the majority of forecasting approaches. To overcome various data-related and other constraints, composite or mixed forecasting methods have been used successfully (Milton, 1975). A mixed method approach is being proposed that could depend on a range of data sources of varying details and quality. The steps in developing the forecasts are:

i. Employment stock in different sectors
ii. Projection of future stock
iii. Required occupational structure
iv. Required educational structure
v. Current stock and flow from actual supply

vi. Supply demand gap

vii. Future strategy on education

Step 1: Stock in Different Sectors

The base year's industry-occupation-education profile of employment is to be derived from the labour force surveys or censuses. Different sectors that are important absorbers of manpower of the disciplines under consideration are to be identified first on the basis of experience, judgment and consultation. Select the most recent year for which data are available as base year. The methods for estimation of employment in different sectors depend on the availability of information. Generally, the following methods can be used:

(a) In the case of sub-sectors for which data on total employment are available from any authentic source, the estimate for base year can be obtained on the basis of trend analysis.

(b) For sub-sectors for which employment data are not available, but data on the number of units are available, the total number of units in the base year is first estimated. Employment per unit can be obtained based on norms available from the secondary sources or from establishment survey. The total employment in the sub-sector can be obtained by scaling.

(c) In the absence of the above, it is possible to make quick forecasts based on the normative approach. This approach provides a simple means for international comparisons and is often used to guide the planning requirements.

Step 2: Projection of Future Stock

Let the total stock in the k^{th} sector at any time 't' be $S_k(t)$. For the base year,'t' equals to zero (0). Estimation of the stock in future years can be made considering the growth rate computed from either the trend data, or growth targeted in the plan documents, or rationalizing the expert opinions. Employment in a given sector can be computed from Equation (1):

$$S_k(t) = S_k(t-1) * (1 + G_k) \quad \ldots(1)$$

where, $S_k(t)$ is the total stock in the k^{th} sector in the t^{th} year, $S_k(t-1)$ is the stock in the k^{th} sector in the previous year, and G_k is the growth rate of the stock in the k^{th} sector.

The projection of future stock can be made for a number of alternative scenarios based on past trends, target growth rates, planned future targets and likely achievements based on judgment and consultation with experts. Alternative forecasts are to be made sub-sector-wise and aggregated by discipline. In all the sub-sectors, it is desirable to attempt at least three alternative scenarios — one considering the current growth of sub-sectors, and second based on relatively higher or lower growth envisaged by experts or government, and third the average of these two.

Step 3: Required Occupational Structure

Stock in a sector consists of employees from different occupational groups. The growth prospect of each occupational group is often different from the other. Therefore, it is preferable to forecast human capital for each occupational group independently. These could be aggregated to reflect a composite picture. Suppose there are 'j' occupational categories in the sector 'k' and the proportion of occupation 'j' in the employment of sector 'k' is $a_{jk.}$ Then, the total stock in occupation 'j' in sector 'k' (i.e., S_{jk}) is given by Equation (2):

$$S_{jk}(t) = a_{jk}(t) * S_k(t) \quad \ldots(2)$$

There are various ways of deciding the value of a_{jk}, the future occupational distribution — (a) assume no changes in the current occupational distributions, (b) study past trends, where data are available, in the occupational structure and extrapolate, (c) make international comparisons assuming that the occupational structures in the less-developed countries would gradually move towards those in the more-developed countries, (d) make inter-firm comparisons assuming that the structures would gradually move towards those in the advanced firms, or (e) use appropriate norms in cases where applicable.

On completion of the forecast of total stock in the j^{th} occupation of the k^{th} sector, it is disaggregated at different educational levels on the basis of proportion of employees by education level, i.e. certificate/ diploma/ UG/ PG/ PhD, either obtained from any data source or from establishment survey for the base year. This gives the occupational structure of work force by the level of education. The stock of the i^{th} education level in the j^{th} occupational group in the k^{th} sector of employment is given by Equation (3):

$$S_{ijk}(t) = e_{ijk}(t) * S_{.jk}(t) \quad \ldots(3)$$

where, $S_{ijk}(t)$ is the stock of the i^{th} education level in the j^{th} occupation of the k^{th} sector in the t^{th} year, and $e_{ijk}(t)$ is the proportion of stock of the i^{th} education level in the j^{th} occupation group of the k^{th} sector in the t^{th} year

The disaggregation can be carried out by assuming that the present composition of the workforce would continue in the future also. If there are significant changes in the proportion of graduates from the education system, in such cases, or where necessary, some judgmental adjustments can be made. These steps lead to the estimates of stock by occupational group-wise and education level-wise for the base year and future.

Step 4: Required Educational Structure

The translation of these occupational forecasts into educational forecasts is a straightforward one. The total stock (S_i) of educational level 'i' over all occupational groups in the k^{th} sector would be as under:

$$S_{ik}(t) = \sum_1^j S_{ijk}(t) \quad \ldots(4)$$

and the total stock of the i^{th} educational level over all the sectors is:

$$S_i(t) = \sum_1^k S_{ik}(t) \quad \ldots(5)$$

The total stock projected at all the levels of education is given by Equation (6):

$$S(t) = \sum_1^i S_i(t) \quad \ldots(6)$$

It is the projection for the total stock requirement in the forecast year.

Step 5: Current Stock and Flow from Actual Supply

The supply of human resources in the target year equals the incremental stock of an educational category, plus the number of fresh entrants into the labour market during the forecast year, less the number due to attrition, i.e. going out of the labour market for reasons such as deaths, retirements, higher educational needs and occupational or spatial migration. The required annual flows of human resource in each year can be derived from the stock estimates taking into account:

(i) annual increment, being the excess of stock demand over the previous year;

(ii) requirement due to attrition, and

(iii) adjustment for the fact that in any year, a number of alumni would be pursuing higher education and, therefore, would not be available for labour market.

(a) Estimation of Replacement Needs

The total attrition factor comprises depletion of manpower stocks due to retirements, deaths, migrations and other factors like voluntary withdrawal from labour force. The data on retirement can be taken from the average age of retirement in government and other organizations. Similarly, data on deaths can be derived from the population census.

For information on migration and the extent of withdrawal of manpower from labour force due to other factors like disability, shift to other fields of activity, and voluntary abstinence from economic activity may not be easily available in many developing countries. Some estimates of this can be made from employees and employers survey, discussions with manpower departments in a number of organizations or by analogy in the related sectors in the country. The combined effect of all these factors would be normally less than one per cent. In the absence of such information leading to these factors, it can be assumed on an ad hoc basis based on experts' views.

The overall attrition rate normally ranges from two to three per cent of the manpower stock. This rate can be used in determining the annual flows of manpower required. The annual flow 'F(t)' required in the t^{th} year at an attrition rate of 'r' is given by Equation (7):

$$F(t) = S(t) - S(t-1) + r * S(t-1) = S(t) - (1-r) * S(t-1) \quad \ldots(7)$$

Similarly, the required annual flow for various levels of education is given by Equation (8):

$$F_i(t) = S_i(t) - (1-r) * S_i(t-1) \quad \ldots(8)$$

The various levels of education require certain numbers a year after the qualifying level. Considering this time lag, the required annual outturn '$O_i(t)$' to meet the annual flow at the level 'i' in the year 't' would be:

$$O_i(t) = F_i(t) + F_{(i+1)} \quad (t + \text{time lag for 'i+1' level}) \quad \ldots(9)$$

The total annual outturn for any educational sector would be the sum of outturns projected for all the levels.

Step 6: Supply Demand Gap

The data on current level and pattern of employment and the current shortages and surpluses are to be calculated for the base year or for a year reasonably close to it. The difference between the estimated annual flow (O_t) and the actual number passed (P_t) from education system is equal to the demand-supply gap (D_t) in the t^{th} year. The education level-wise gaps are computed using Equation (10):

$$D_i(t) = O_i(t) - P_i(t) \qquad \ldots(10)$$

Step 7: Future Strategy on Education

The gap estimates give the likely additional outturns required from the educational system in the future years. The corresponding intake levels would then depend on the outturn-intake ratios (Q_i) and the proportion of participation in economic activities (E_i) after completing the education. The desired additional intake level 'A_i' for the educational level 'i' can be expressed by Equation (11):

$$A_i(t) = D_i(t) / [Q_i(t))*E_i(t)] \qquad \ldots(11)$$

The data on supply, demand and the gap form the basis for developing the future strategy on education. This information has to be analysed keeping in view the qualitative aspects. At times the education system may produce enough graduates, but it may not fulfill the needs of the employment sector in terms of their affordability, skills, etc. Apart from the quantitative data, qualitative information on related employability, availability of graduates and adequacy of the education received are to be collected through employment survey, alumni survey and discussions with various stakeholders.

Application of Mixed Method to Indian Agricultural Sector

The mixed methodology framework was adopted recently for making forecasts about human resource in the agricultural sector of India in a study undertaken by the National Academy of Agricultural Research Management (NAARM) and the Institute of Applied Manpower Research (IAMR) during 2009-11 (Rama Rao *et al*., 2011).

The two basic issues addressed through this study were forecasting of the number of graduates, postgraduates and doctorates (collectively called graduates) and the need of human capital at the sub-graduate level (diploma holders), the number likely to be available over the next ten years, and the quantitative and qualitative skill gaps.

The manner in which supply and demand are estimated using various forecasting tools are elaborated below.

Supply Forecast

In India, the decennial population census collects information on the number of graduates and post-graduates by qualifications, sex and age which include the agricultural (including dairy sciences) and veterinary sciences also. The latest available Indian Census Data relate to the year 2001and another major problem about data on technical graduates is the level of underestimation. It would, therefore, be difficult to rely on the census data for assessing the level of supply of agricultural human capital. Moreover, 2001 data cannot provide the current picture.

The other possible source is the five-yearly household sample surveys conducted by the National Sample Survey Organization (NSSO, 2011) on the labour force, employment and unemployment. The latest survey in this series relates to the year 2009-10, the base year for the current study. However, NSSO surveys adopt a 12- category classification of the labour force by educational levels, in which there is just one category covering all the technical graduates — engineering, medical, agriculture, etc., from which it is not possible to get separate data for the agricultural graduates.

In view of the above data problems, it has become necessary to estimate the base year (2010) supply of agricultural human capital in the country indirectly through cumulation of annual institutional outturns. Assuming that the average age at the entry of agricultural graduates into the labour force is 22 years and at exit is 60 years, the working span of agricultural graduates comes out to be 38 years. In the case of post-graduates and doctorates, the entry age may be taken as 24 years and 27 years, respectively, implying a working span of 36 years and 33 years, respectively. Since graduates form about two-thirds of the total outturn, it has been assumed that the average active working span of agricultural scientists is 37 years. The annual attrition due to mortality, migration and non-participation in work is taken as three per cent.

To assess the base year stock for different categories of agricultural graduates, it is necessary, in this approach, to have data on the annual outturns of alumni classified by disciplines from the year 1974 to cover the span of 37 years by 2010. The data problems surfaced even in this indirect estimation of supply stock as a continuous series of outturn data was not available from one source and a number of sources had to be tapped to build up the time series.

The basis for assessing the supply of agricultural human resources is the annual institutional output from the education division of ICAR supplemented with the data available from the National Information System on Agricultural Education Network in India (NISAGENET) maintained by the Indian Agricultural Statistics Research Institute (IASRI, 2010). In the case of agricultural universities and research institutions, the coverage was on a census basis. In the case of colleges, offering agricultural and allied programmes that are affiliated to state agricultural universities (SAUs) or other universities, data on students and faculty were obtained directly from the colleges.

Demand Forecast

These projections were derived following the mixed methodology described above. Some salient points pertinent to the study carried out in India during 2009-11 are:

- Sub-sectors crops, horticulture, forestry, dairy, fisheries, veterinary, agri-engineering and agri-biotechnology have been identified as important in the agriculture and allied sector. These eight sub-sectors have employees in the functional areas like government services, finance, processing industry, research, education, etc.
- The data on occupational structure of the employees are not available uniformly in all the occupations. Thus, occupational profiles have not been estimated. In view of this, the total employment has been translated into educational levels directly.
- The qualitative aspects of human capital needs have been captured through about 50 focus group discussions with various stakeholders and experts covering different regions of the country. These stakeholders included university faculty, research institutions scientists, industry personnel, industry associations, farmers and farmers associations, non-governmental organizations, etc.
- An extensive and detailed employment survey covering 3500 agricultural establishments from 103 selected districts was carried out for establishing the base-line data (for the year 2010) on the current level and pattern of employment.
- Expert opinions on the adequacy of education received in the agricultural universities in securing jobs and in handling the jobs were obtained from 4200 individual agricultural experts working in various establishments.
- Trends in the utilization pattern of the output of agricultural universities were obtained from tracer studies covering 2105 recently passed out alumni. This survey provided information on employment by type, self-employment by nature, unemployment, migration to higher education or other occupations, staying out of labour force and perceptions about the skill gaps with reference to labour market.

Estimation of Manpower Replacement Needs

The total attrition factor comprises depletion of manpower stocks due to (a) retirements, (b) deaths, (c) migration, and (d) other factors like voluntary withdrawal from labour force, etc. The agricultural manpower attrition rates for the projection period 2010 to 2020 were estimated in the following manner:

Retirements — The average retirement age was taken as 60 years. On the basis of available information on the supply of graduates, the total attrition due to retirements worked out to be 9,000 during the projection period. The total required stock of agricultural graduates and above in 2010 was about 4,62,000. The annual attrition rate due to retirements would be around 1.95 per cent of the stock.

Mortality — For estimating attrition due to mortality, it was assumed that the mortality pattern among the urban population in the age group of 20-60 years would be relevant for the agricultural manpower stock. The annual losses due to mortality among urban population in the working age-groups were, thus, about 3.5 per 1000 or 0.35 per cent. Together with retirements, this raises the annual rate of attrition to 2.3 per cent.

Migration and other Factors — No information was available on the migration of agricultural graduates to other countries, though the phenomenon was there. Similarly, no information was available about the extent of withdrawal of agricultural manpower from labour force due to other factors like disability, shift to other fields of activity, and voluntary abstinence from economic activity. The combined effect of all these factors has been assumed to be 0.7 per cent on an ad hoc basis.

Overall Rate of Attrition — The overall attrition rate, thus, may be placed at about three per cent of the manpower stock in all the disciplines, with the exception of bio-technology. Being of recent origin and having young work force, the attrition rate has been assumed to be only one per cent for mortality and other factors.

Alternative Forecast Scenarios

In all the sectors of agriculture, forecasts have been made based on two scenarios — one, considering the current growth of sector and sub-sectors, and the other, a relatively higher growth as envisaged by the Planning Commission, their schemes and flagship programmes, vision of various sectors, etc. After providing the forecasts on the basis of these two scenarios, the study has recommended the average of the two. These growth scenarios and recommendations have been made keeping in view the interactions with experts in the focus group discussions.

The Forecast Results

The sub-sectors for which total employment data were available are given in Table 2 and the sub-sectors for which employment data were estimated based on the number of units are shown in Table 3. The assessment results of the supply in 2010 and the demand by 2020 for human resources in various sub-sectors of agriculture are given in Table 4 (For more details *see* Rama Rao *et al*., 2011).

In 2010, the existing education system produced about 24,000 graduates in the eight disciplines of agriculture with crop sciences contributing two-thirds. The projections indicate that by 2020 the annual outturn required would have to be about 54,000, indicating a demand-supply gap of 30,000.

Discussions

Forecasting, in general, is an exercise subject to hazards posed by unforeseen changes in the course of development and emergence of phenomena not visualized at the time of forecasting. It is more so in the case of manpower forecasts where, apart from technological changes, uncertainties emerging from human behaviour are also involved.

Table 2. Sub-sectors for which total employment data are available

Sub-sector	Source	Nature of data
Banks	Banking Statistics of Reserve Bank of India	Number of officers and others year-wise, latest being 2008-09
Processing industries (like dairy, fruit, meat, fish, etc.) and input / output industries like fertilizers, pesticides, agricultural equipment, animal feed, paper, pharmaceuticals, wood processing, etc	Annual Survey of Industries, Central Statistical Organisation	Total employment, number of factories, year-wise, latest being 2005-06
Government departments dealing with the subsector	Website of the respective departments	Total employment classified by posts
Indian Council of Agricultural Research (ICAR) institutions	PERMISNET of ICAR	Data obtained from ICAR
Teaching staff	Institutional schedules from agricultural universities	Data on teachers by qualifications and field 2009-10

Table 3. Sub-sectors for which employment data were estimated based on number of units

Sub-sector	Source	Nature of data
Seeds	Seed Producers' Association	Number of units of different sizes, 2009-10
Nurseries	XI[th] Plan Working Group on Horticulture, National Horticultural Mission	Number of nurseries in 2003-04 and year-wise new nurseries for subsequent years
Dairy plants	Animal Husbandry Statistics, Department of Animal Husbandry, (published in IASRI data books for various years)	Number of plants and processing capacity in cooperative, private and publics sectors
Aqua-culture units	Coastal Aqua Culture Authority web-site	No. of units of different sizes in 2009-10
Fishing equipment	IASRI data book for various years	Vessels of different types

Table 4. Sector-wise supply (in 2010) and demand (by 2020) of human resources in agriculture at different educational levels

Discipline	Undergraduates		Postgraduates		PhDs		Undergraduates & above	
	2010 supply	2020 demand	2010 supply	2020 demand	2010 supply	2020 demand	2010 supply	2020 demand
Crop science	11852	18659	3514	5422	583	1203	15949	25284
Horticulture	1001	7295	409	993	55	330	1465	8618
Forestry	386	1260	275	416	55	156	716	1832
Veterinary & AH	1761	5332	797	1854	125	486	2683	7672
Fisheries	285	2096	109	418	30	100	424	2614
Dairy technology	255	2605	30	503	25	207	310	3315
Agri-engineering	1218	2359	262	709	27	189	1507	3256
Agri- biotechnology	558	582	156	323	20	134	734	1039
Total	17316	40188	5553	10638	920	2805	23788	53630

The relevance and validity of manpower forecasts require both access to accurate information and use of appropriate conceptual and analytical techniques. The most common mix encountered in the literature associates the supply-based and the requirement-based parameters, which permits the performance of gap analysis for future years and taking action to make supply match requirements. However, responsive planning for the future workforce remains necessary, as rapid changes are taking place in the supply and the requirement. Maintaining this balance requires continuous monitoring, and careful choices given the realities of the country, and the use of research evidence to ensure that population needs are addressed effectively. The value of projections lies not in their ability to get the numbers exactly right but in their utility in identifying the current and emerging trends to which policymakers need to respond (Dominique Roberfroid, 2009).

The paper has presented yet one more way of projecting demand of human resource using modified Parnes approach. The crux of the Parnes method is the projection of future employment in different sectors of the economy and splitting it first among occupations and then across educational levels, starting with the existing patterns as the base and moving forward on the basis of trends, experts' opinions, etc. Projecting total employment sector-wise is less complicated and is routinely done in the Indian development plans, at least for the major economic sectors. It is the other steps of splitting the total employment into occupational and educational forecasts that presents severe data problems. The conventional Parnes' approach pre-supposes the availability of elaborate data on the current employment in different sectors and its occupational distribution and a matrix of relationships between occupation and education, preferably as a time series. Such data would generally be available in the developed world. But in the developing countries like India, these data are not available to the degree of disaggregation required or are not of the desired quality. Therefore, it has to be built up using various methods.

One of the objections in using Parnes model is the assumption that there is a fixed relationship between skill levels and education required. In the present study, this issue has been skirted round by translating the total employment to education directly without the intervening step of occupational profiles. To that extent the modified Parnes approach has enabled a pragmatic assessment of the future human resource requirements in agriculture.

Conclusions

The data problems encountered in the study on forecasting the agricultural manpower in India are common to most of the sectors of the economy for forecasting not only in India but other developing countries as well. Under these circumstances, application of one single method for forecasting may neither be feasible nor appropriate. Hence, a mixed methodology approach has been followed in this paper. A variety of pragmatic approaches have been adopted ranging from detailed trend analysis of data where time series data are available to assessments on the basis of qualitative information collected through experts' opinions. In between, normative methods have been used for forecasting and on some occasions, to develop the base line employment data where the latter are not available.

The future scenarios have been visualized on the basis of the planned growth, investments, desirable developments and vision documents besides taking into account the experts' opinions from various stakeholders. The use of mixed methodology in the present study has helped in arriving at logical conclusions so far as the future requirements of human resource in various fields of agriculture are concerned.

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References

AFF (2000) *Study on Assessment of Manpower Needs and Development*, A report prepared for CCS HAU, Hissar, Haryana by M/s A.F. Ferguson & Co., Delhi.

Bartholomew, D.J. and Forbes A.F. (1979) *Statistical Techniques for Manpower Planning,* Wiley, Chichester (Eng.), New York.

Deane, R.T. and Yett, D.E. (1979) Nurse market policy simulations using an econometric model. *Research in Health Economics*, **1**: 255-300.

Dominique, Roberfroid (2009) Christian Leonard and Sabine Stordeur, Physician supply forecast: Better than peering in a crystal ball?, *Human Resources for Health,* **7**: 7-10.

Drandell, Milton (1975) Composite forecasting methodology for manpower planning utilizing objective and subjective criteria, *Academy of Management Journal,* 18(3): 510-519.

ESCAP (Economic and Social Commission for Asia and the Pacific) (1999) *Human Resource Development of the Tourism Sector in India*, New York. http://www.unescap.org/ttdw/Publications/TPTS_pubs/pub_2020_tor.pdf

IAMR (Institute of Applied Manpower Research) (1979) *Agricultural Manpower Planning, Training and Utilization, Country Profile Study - India.* FAO, Rome.

IAMR (Institute of Applied Manpower Research) (2001) *Assessment of National Manpower Needs in Agriculture and Allied Sector*. New Delhi.

IASRI (Indian Agricultural Statistics Research Institute) (2010) *Agricultural Research Data Book* (various years) and PEMISNET II data (as on 23/4/2010), & Indian Council of Agricultural Research, New Delhi.

Kerr, Norbert L. and Scott, Tindale R. (2011) Group- based forecasting?: A social psychological analysis. *International Journal of Forecasting,* **27**: 1.

Tau, Lee Hong and Sheu, Hua Chen (2001) Fuzzy regression model with fuzzy input and output data for manpower forecasting. *Fuzzy Sets and Systems*. 119: 205-213.

Mohapatra, P.K.J., Mondal, P. and Saha, B.K. (1990) Modelling age and retirement in manpower planning. *International Journal of Manpower,* **11**(6): 27-31.

Mondal, P., Mohapatra, P.K.J., Jain, A. and Sangh, V.K.C. (1992) Analysis of scientific manpower flow scenarios for an R&D organization. *Journal of Scientific and Industrial Research,* **51**: 685-692.

Nichakorn, Sirikanokwilai, Wibulpolprasert Suwit and Pengpaiboon Paichit (1998) Modified population-to-physician ratio method to project future physician requirement in Thailand, *Human Resources for Health Development Journal*, **2**(3): 197-209.

NSDC (National Skill Development Council) (2010) *Report on the Human Resource and Skill Requirements in the Food Processing Sector in India, Skill Gap Analysis Reports*, New Delhi. Available at http://www.nsdcindia.org/knowledge-bank/index.aspx

NSSO (National Sample Survey Office) (2011) *Employment and Unemployment Situation in India, 2009-10,* NSSO Report No. 537, Ministry of Statistics and Programme Implementation, Government of India, New Delhi. http://mospi.nic.in/Mospi_New/site/inner.aspx?status=3&menu_id=31\

Ozay, Mehmet (1977) The role of manpower planner in developing countries, *Industrial Relations Journal*, **7**(3): 66-74.

Parnes, H.S. (1962) *Forecasting Educational Needs for Economic and Social Development,* OECD, Paris.

Psacharopoulos, George (1973) An input-output model for the assessment of labor skill requirements. *Higher Education*, **2**(4): 461-474.

Psacharopoulos, George (1984) Assessing training priorities in developing countries: Current practices and possible alternatives, *International Labour Review*, **5**: 569-583.

Psacharopoulos, George (1991) From manpower planning to labour market analysis, *International Labour Review*, **130**(4): 459-474.

Raghavendra, B.G. (1991) A bivariate model for Markov manpower planning systems. *The Journal of the Operational Research Society,* **42**(7): 565-570.

Rama Rao, D., Nanda, S.K. and Sriram, C. (2005) *Forecasting Trained Agricultural Manpower*, NAIP Sponsored NAARM Publication, Hyderabad.

Rama Rao, D., Agrawal, Rashmi, Nanda, S.K., Awasthi, I.C., Joshi, G.P., Bhattacharya, Sanchita, and Indra Kumar, D. (2011) *Assessment of Future Human Capital Requirements in Agriculture and Allied Sectors*. NAIP Project Report, National Academy of Agricultural Research Management, Hyderabad, India. 411 p.

Rowat, R. (1983) *Trained Manpower for Agriculture and Rural Development*, FAO Pub No. 10, FAO, Rome.

Shivanagaraju, C., Manhanty, B., Vizayakumar, K. and Mohapatra, P.K.J. (1998) Beta-distributed age in manpower planning models, *Applied Mathematical Modelling,* **22**: 23-37.

Škulj, Damjan, Vasja, Vehovar and Darko, Štamfelj (2008) The modelling of manpower by Markov Chains – A case study of the Slovenian armed forces. *Informatica*, **32**: 289-291.

Song, F. and Rathwell, T. (1994) Stochastic simulation and sensitivity analysis: Estimating future demand for health resources in China, *World Health Statistics Quarterly*, **47**: 149-156.

Susiganeshkumar, E. and Elangovan, R. (2010) Prediction of manpower wastage in Tamil Nadu software industry using Cox's regression approach. *International Transactions in Mathematical Sciences and Computer*, **3**(1): 27-44.

TCS (Tata Consultancy Services) (2000) *Study of Manpower Needs of the Agriculture Sector in Tamil Nadu*. Government of Tamil Nadu, Chennai.

Timbergen, J. and Correa, I.H. (1962) Quantitative adaptation of education to acceleration of growth, *Kyklos*, **XV**.

Trivedi, V., Moscovice, I., Brass, R. and Brooks, J. (1987) A semi-markov model for primary health care manpower supply prediction, *Management Science*, **33**: 149-160.

Willems (Ed) (1996) *Manpower Forecasting and Modelling Replacement Demand: An Overview.* Research Centre for Education and the Labour Market. ROA-W-1996/4E, Maastricht University, Maastricht. Available at http://edocs.ub.unimaas.nl/loader/file.asp?id=528 .

World Bank (2006) *Skill Development in India: The Vocational Education and Training System*, Human Development Unit, South Asian Region.

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