The Long-Term Food Outlook for India

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THE LONG-TERM FOOD OUTLOOK FOR INDIA

In recent years, there has been significant interest among researchers to evaluate the long-term food situation in China, particularly since Lester Brown of the World Watch institute stated that "China will starve the world." But less attention has focused on analyzing the long-term food situation in India, the world's second most populous country, and Asia's third largest economy. Since the late 1980s, market-oriented domestic and trade policy reforms have accelerated economic growth in India. If this recent growth becomes broad based, India too is likely to place greater demand on the world food system in the future (Thompson 1997). Thompson (1997) also emphasized that more attention should be paid to India, despite recent attention to China.

The United Nations now projects that by the middle of the next century the Indian population will actually exceed that of China (1.5 billion compared with 1.4 billion in China) and more than 55 percent of the Indian population will live in urban locations (26 percent in 1996). Even more important, India has more than 250 million middle-class consumers and is likely to grow with economic prosperity. Income growth, urban-rural population composition, family size, and many other demographic factors are likely influence diet preferences significantly. But dietary changes in India may not be similar to most other countries because it is predominantly vegetarian.

In contrast to consumption, Indian agricultural production has slowed significantly in the 1990s. Growth in grain production has declines from 3 percent in the 1980s to only 1.75 percent in the first six years of the 1990s. The growth of agricultural production from the mid-1960s has been from a sustained rising trend in yields. The three inputs—irrigation, fertilizers, and high-quality seeds—have accounted for much of the yield growth. One explanation for declining production growth is less fertilizer use. Other factors affecting production may be the less irrigated area and lower fixed capital stock in agriculture. But of more importance, the crop production growth rate is declining at a rate higher than the inputs in recent years (Brahmnanda 1997).

Because the growth rates of consumption and production are moving in opposite directions, it should be of concern to Indian policymakers and researchers should pay more attention to analyzing the future food outlook for India. This study provides long-term demand and supply projections for cereals including wheat, rice, corn, sorghum, and other grains.

Demand projections are made separately for five income groups within urban and rural categories to capture impacts of rural-urban population composition and unequal income response on consumption. This is particularly important for a country like India with vast geographical and cultural diversity, where consumption patterns are likely to vary substantially across regions, rural/urban sectors, and income groups. On the supply side, the production of each crop is calculated by estimating both area and yield. Area under each crop is estimated by taking into account total availability of land, cropping intensity, and loss of land due to urbanization and perennial crops.

Demand Estimation

Food Demand

Demand projections include various grains (wheat, rice, corn, sorghum, and other grains), meats (chicken and other meats), and livestock products (eggs and milk). Meat, eggs, and milk are included to accurately estimate feed utilization of various grains. There are two primary ways to determine the projected demand for food grains and other consumption necessities (Brhmananda 1997). The first approach is to postulate a different value of the growth rate of real national income and then calculate the growth rate of demand for food commodities on the basis of estimates of income elasticity of demand for agricultural commodities. The second approach is to project alternative values for the growth rate of employment and then derive the growth rate of agricultural commodities on the basis of employment elasticity of demand for agricultural commodities.

In this study, demand projections are made using the income elasticity approach. The decision to use this approach is based on the availability of data. The 1993-94 consumer expenditure data from the National Sample Survey Organization of India were used to estimate Engle curves and income elasticities of demand separately for rural and urban. A large number of alternative functional forms are possible for modeling the Engle curve, which is the relationship between food demand and income levels. Double-log specification has been used widely because of its simplicity and readily interpretable properties.

Double Log: $Ln(Y) = a + b*Ln(X)$
Where Y = quantity consumed, and X = income level.
Income Elasticity = b

But this functional form is not theoretically desirable because of its limitation that all food consumption is expected to increase with rising income levels. Other functional forms include semi-log, log-log inverse, and log-quadratic.

Semi-Log: $Y = a + b*Ln(X)$
Income Elasticity = b/Y

Log-Log inverse: $Ln(Y) = a + b/X+c*Ln(X)$
Income Elasticity = $b/X-c$

Log Quadratic: $Ln(Y) = a + b*Ln(X) + c*Ln(X)^2$
Income Elasticity = $b + 2*c*Ln(X)$

These three alternative functional forms of the Engle curve were estimated through regression analysis using the data from 1993-94 consumer expenditure data. All three provide good fit. But the log-quadratic functional form appears to be better for most commodities, particularly milk, eggs, and meats. Estimates of the log-quadratic form of Engle equations for rural population are in Table 1 and for urban population are in Table 2. High R^2 for most of the equations verifies that the log-quadratic specification provides a better fit. The Engle equation was used to project demand for five different income groups, in both urban and rural areas.

Table 1. OLS Estimates of Engle Equation for Rural Population

Commodity	Constant	Ln(income)	$Ln(income)^2$	R^2
Rice	-21.01 (0.07)	6.11 (0.95)	-0.37 (0.06)	0.90
Wheat	-0.57 (0.04)	0.65 0.61	-0.01 (0.02)	0.98
Maize	16.61 (0.09)	-3.29 (1.32)	0.18 (0.08)	0.84
Sorghum	26.87 (0.07)	-5.54 (1.05)	0.31 (0.06)	0.96
Other Grains	-10.65 (0.08)	3.23 (1.13)	-0.20 (0.07)	0.99
Milk and Milk Products	-42.59 (0.04)	9.91 (0.51)	-0.51 (0.03)	0.99
Eggs	-39.24 (0.04)	8.57 (0.44)	-0.41 (0.04)	0.98
Chicken	-13.92 (0.14)	1.92 (1.61)	-0.04 (0.14)	0.97
Other Meats	-12.6 (0.13)	1.92 (1.61)	-0.04 (0.14)	0.97

Table 2. OLS Estimates of Engle Equation for Urban Population

Commodity	Constant	Ln(income)	Ln(income)^2	R^2
Rice	-11.93	3.77	-0.22	0.77
	(0.08)	(0.87)	(0.05)	
Wheat	-3.97	1.72	-0.09	0.97
	(0.02)	(0.22)	(0.01)	
Maize	3.05	-0.02	(0.23)	0.67
	(0.35)	(4.03)	0.19	
Sorghum	24.32	-4.3	0.19	0.95
	(0.17)	(1.89)	(0.11)	
Other Grains	-39.78	10.23	-0.64	0.97
	(0.09)	(1.10)	(0.06)	
Milk and Milk	-29.32	6.81	-0.34	0.99
Products	(0.03)	(0.48)	(0.06)	
Eggs	-23.90	5.05	-0.22	0.99
	(0.03)	(0.34)	(0.02)	
Chicken	-6.59	1.00	-0.03	0.97
	(0.04)	(1.59)	(0.02)	
Other Meats	-5.16	1.00	-0.03	0.97
	(0.05)	(1.59)	(0.02)	

Table 3. Income Elasticities for Different Income Groups in Rural Areas at the Mean Expenditure Level

Commodity	Quintile One	Quintile Two	Quintile Three	Quintile Four	Quintile Five
Wheat	0.495	0.489	.484	0.479	0.469
Rice	0.715	0.471	0.307	0.120	-0.210
Sorghum	-0.958	-0.750	-0.611	-0.453	-0.172
Maize	-0.625	-0.505	-0.424	-0.332	-0.169
OCG	0.303	0.171	0.082	-0.019	-0.198
Milk and Milk Products	2.346	1.958	1.697	1.401	0.876
Eggs	2.443	2.165	1.979	1.767	1.393
Chicken	1.346	1.320	1.303	1.283	1.248
Other Meats	1.346	1.320	1.303	1.283	1.248

Table 4. Income Elasticities for Different Income Groups in Urban Areas at the Mean Expenditure Level

Commodity	Quintile One	Quintile Two	Quintile Three	Quintile Four	Quintile Five
Wheat	0.316	0.247	0.194	0.133	0.035
Rice	0.386	0.221	0.094	-0.053	-0.287
Sorghum	-1.382	-1.239	-1.129	-1.003	-0.801
Maize	-0.598	-0.626	-0.648	-0.673	-0.713
OG	0.451	-0.027	-0.395	-0.818	-1.495
Milk and Milk Products	1.637	1.384	.189	0.966	0.607
Eggs	1.724	1.562	1.437	1.293	1.062
Chicken	0.477	0.452	0.432	0.409	0.373
Other Meats	0.477	0.452	0.432	0.409	0.373

The income elasticities for five different income groups (quintiles one to five) in urban and rural areas are reported in Tables 3 and 4. Each quintile accounts for 20 percent of the population and increases with income; that is, quintile one is the poor and quintile five is the rich. As expected, income elasticities are higher for rural than for urban across all commodities and income groups and decreases as the income level rises. For example, the income elasticity of quintile one for wheat is 0.495 and 0.316 for rural and urban. It is also interesting to note that as income rises, the income elasticity for wheat in rural areas decreases from 0.495 to 0.469 but the same decrease is from 0.316 to 0.035 in the urban area. Rice has positive income elasticity for lower income groups and turns to negative for higher income groups, both in urban and rural areas. Other grains, such as maize and sorghum, have negative income elasticities across income groups, with the exception of some positive income elasticities for lower income groups in the case of other coarse grains.

Another interesting result is the magnitude of elasticities for both livestock and livestock products. Unlike other emerging markets, income elasticities for milk and eggs are found to be much higher than the meat elasticity. For example, income elasticity for eggs is 1.724 compared with 0.477 for chicken for quintile one in urban areas. As income rises, the income elasticity for eggs decreases but still remains high for higher income groups. For example, it is 1.062 for quintile five in rural areas. This suggests that possible future economic growth may not bring growth in Indian meat consumption similar to the growth in other developing countries, particularly China.

Since expenditure growth is the primary factor influencing food consumption in a developing country like India, it is important to project expenditure growth using an accurate variable. Generally, expenditure growth is assumed to be the same as GDP growth. GDP generally includes not only private consumption but also private investments, imports, exports, and government spending. Thus, it is likely that food expenditures will follow private consumption more closely than general economic indicators such as GDP. Thus, any attempt to estimate food demand should link food consumption with private consumption rather than a general economic indicator such as GDP. Keeping this in mind, in this study, consumption expenditure growth is calculated from private consumption rather than GDP.

Feed Demand

The demand for grain as feed is modeled using the relationships in the equations $d_i = \sum c_{ij} * X_j$ where demand for feed of ith grain $\left(d_i\right)$ is the sum of feed required to produce a unit of meat J $\left(X_j\right)$. Meats, eggs, and milk were converted to feed equivalents using their respective conversion factors. Within each sector, separate feed conversion factors were used for different production types. For example, milk production was divided into organized and unorganized production while egg and chicken production were divided into intensive and traditional production systems. The unorganized milk sector was divided into small and large farmers.

In India, the organized sector accounts for only 14 percent of total milk production, whereas the remaining 86 percent comes from the unorganized sector. Within the organized sector, landless labor, small and medium farmers account for 75 percent and large farmers account for 25 percent. The feed conversion factor for each production type was calculated Using data from various journal articles published in the *Indian Dairy Science Journal*. These studies have reported both feed consumed and milk yield per cow for different production types such as commercial, large farmers, and small farmers. Information on percentage of each grain in the feed was obtained from SWOMPSIM.

Unlike milk, a large proportion of chicken (60 percent) and eggs (56 percent) are produced using the intensive production system. Information on feed conversion factors and composition of feed was obtained from SWOMPSIM. Lamb meat production was converted into feed equivalent using a single conversion factor.

As the production of meat, milk, and eggs increases because of rising demand, it is likely that structural change will take place in livestock sector. The rate of structural change is linked to the growth rate of urban consumption. For example, in 1993, 32 percent of total production was consumed by urban population and this proportion is projected to increase to 46 percent by 2030. Correspondingly, the share of the organized sector for total milk production was projected to grow from 14 to 21 percent. Similarly, intensive egg and chicken production are projected to grow to 72 to 68 percent by 2015.

Table 5. Feed Conversion Ratios

			Feed Composition			
Commodity	Production Type	FCR	Corn	OCG	Soy Meal	Others
Milk	Organized	0.29	16	21	3	60
	Unorganized					
	Small	0.08	10	10	3	77
	Large	0.18	16	15	3	66
Eggs	Intensive	2.45	9	16	3	72
	Traditional	3.5	4.5	8	1.5	86
Chicken	Intensive	2.29	14	0	4	82
	Traditional	3.3	7	0	2	91
Lamb		0.16	11	29	3	57

Notes: FCR-Feed Conversion Ration
OCG Other Coarse Grains (Barley, Millet, Ragi and Sorghum)
Others-Bran, other meals.

Supply Side Estimation

India's gross sown area is estimated by multiplying net sown area and cropping intensity. Cropping intensity is estimated as a function of its lag. Similarly, area under permanent and horticultural crops is estimated as a function of its lag and is subtracted from gross sown area to equal net sown area for cereals, oilseeds, cotton, and sugarcane.

Total area under cereals, oilseeds, cotton, and sugarcane is allocated among various crops using a nonlinear supply system, where area harvested of each crop is a function of real gross revenue (real farm harvest price multiplied by yield) of its own and competing crops. The nonlinear supply system is estimated using historical data for 1970 to 1993, with symmetry and homogeneity imposed. The supply system was estimated with a nonlinear least square estimation procedure using the SHAZAM econometric package. One equation was dropped from the system to avoid singularity and symmetry was imposed. The coefficients, along with standard errors, are presented here in a matrix.

Most of the yield equations are estimated as a function of percentage of area under irrigation, percentage of area under high-yielding varieties, fertilizer application per hectare, and rainfall (percentage deviations from normal). Data on reported area, net sown area, not available for cultivation, other cultivated land, fallow land, area under permanent and horticultural crops and copping intensity were collected from various issues of *Fertilizer Statistics*, published by the Fertilizer Association of India.

Data on individual crop area, yield, and minimum support prices were collected from various issues of *Agricultural Statistics at a Glance*, published by the Indian Ministry of Agriculture. Farm harvest prices of each crop for major producing states were obtained from various issues of *Farm Harvest Prices of Principal Crops in India*. All India average farm prices were calculated from a weighted average of state prices. Data on the percentage of area under irrigation, high-yielding varieties by crop, were obtained from various issues of *Agricultural Statistics at a Glance* and *Indian Agriculture in Brief*, published by the Directorate of Economics and Statistics, Indian Ministry of Agriculture.

A log-log specification is used to estimate yield of various crops. The general variables used to estimate yield equations include percentage of area under irrigation, percentage of area under high-yielding varieties, fertilizer application per hectare, and rainfall (percentage deviation from normal). In some cases, one or more of these variables are excluded from the yield equation because of non-availability of data. Table 6 provides the estimates of yield equations for each crop.

Table 6. OLS Estimates of Yield Equations of Various Crops

Commodity	Constant	Percentage of area under irrigation	Percentage of area under HYV	Fertilizer Appl. Per Hectare	Percentage of deviation of rainfall from normal	R^2
Wheat	1.67 (0.00)	0.31 (0.13)	0.23 (0.09)	0.72 (0.28)	0.11 (0.07)	0.97
Rice	1.76 (0.04)	0.26 (0.85)	0.64 (0.31)	0.03 (0.03)	0.41 (0.11)	0.92
Sorghum	5.26 (0.11)	0.34 (0.15)	0.04 (0.09)		0.13 (0.03)	0.52
Maize	3.42 (0.09)			0.51 (0.2)	0.36 (0.06)	0.73
Other Grains	1.29 (0.10)	0.3 (0.18)		0.26 (0.08)	0.76 (0.24)	0.85
Cotton	2.82 (0.11)			0.45 (0.07)	0.15 (0.09)	0.83
Sugarcane	2.77 (0.03)	1.77 (0.19)			0.07 (0.03)	0.87
Soybean	0.65 (0.14)			0.08 (0.02)	1.24 (0.3)	0.76
Rapeseed	1.17 (0.08)	0.37 (0.17)		0.45 (0.26)	0.46 (0.19)	0.96
Groundnut	3.55 (0.13)	0.31 (0.05)		0.06 (0.05)	0.56 (0.23)	0.9

As Table 6 demonstrates, these four variables account for 80 to 90 percent variations in yield for most crops. As expected, rainfall is found to be very important for all crops except wheat. The significance of the rainfall coefficient in the wheat yield equation may be explained by the fact that 90 percent of wheat area is under irrigation and is unlikely to be significantly affected by rainfall. Apart from rainfall, per hectare fertilizer application also strongly affects the yield for most crops. In addition, yields of wheat, sugarcane, rapeseed, and groundnut are also significantly affected by the percentage of each crop’s area under irrigation. The fourth explanatory variable, percentage of area under high-yielding varieties, is found to affect significantly the yields of wheat and rice.

Area Equations

Net sown area = Reported area
-Not available for cultivation
-Other cultivated land
-Fallow land

Ln (Cropping Intensity) = 0.015298
(0.009)
+0.997585 *ln(lag(cropping intensity))
(0.032)

R^2=0.99

Grass sown area = Net area sown * Cropping intensity

Area under permanent and horticultural crops = 0.145
(0.005)
+1.0165*lag (area)
(0.03)

R^2 = 0.99

A1 = Area under cereals + pulses + cotton + sugarcane + oilseeds = Gross sown area

-Area under permanent and horticultural crops

Sugarcane area = 1.53
(0.2)
+0.39*lag (area)
(0.13)
+0.000031 * (soybean farm price * yield / CPI)
(0.00001)

R^2 = 0.87

Cotton area = 2.74
(0.65)
+0.62 * lag (area)
(0.07)
+0.089*(cotton farm harvest price * yield) / (price index of coarse grains * average yield))
(0.016)

$R^2 = 0.91$

Pulses area = 21.55
(3.66)
+1.856 * (Weighted average farm price of gram and moong * yield) / (competing crops gross revenue))
(0.067)

$R^2 = 0.7$

Competing crops gross return = 0.3 * (wheat farm harvest price * yield) + 0.3 * (rice farm price * yield) + 0.4 * sorghum farm price * yield)

Soybean area = 0.189
(0.01)
+0.98*lag (area)
(0.12)
+0.118*(soybean farm price * yield)/(competing crops gross returns))
(0.016)

$R^2 = 0.67$

A2 = A1 – Sugarcane area – Cotton area – Soybean area

where A2 = Area under wheat + rice + maize + sorghum + other coarse grains + rapeseed groundnut.

Area among seven crops is allocated using a supply system. An individual equation in the system may be specified as:

$$A2_i = \alpha_i + \beta\, lag(A2_i) + \sum \gamma_{ij} (P_j * Y_j / CPI)$$

where i and j = 1, 2…7, A_i = area under i^{th} crop, P_j = farm harvest price of j^{th} crop, Y_j = average yield of j^{th} crop, and CPI = Consumer price index.

Table 7. Supply Estimates of Various Crops

			Real Gross Revenue						
Crop	Const.	Lag(A)	Wheat	Rice	OCG	Sorghum	G. Nut	R.Seed	Maize
				Farm Price* yield/CPI					
Wheat	9.35	0.469	0.0006	-0.00003	-0.00065	0.0003	0.0002	-0.0002	0.000007
	(2.4)	(0.02)	(0.0003)	(0.0004)	(0.0004)	(0.0002)	(0.000)	(0.0001)	(0.0005)
Rice	22.95			0.0006	-0.0013	-0.00074	0.00004	0.0002	-0.0003
	(4.1)			(0.0003)	(0.0006)	(0.0004)	(0.0002)	(0.0001)	(0.001)
OG	19.15				0.0035	-0.0017	0.0014	-0.0013	-0.0023
	(5.03)				(0.0012)	(0.0004)	(0.003)	(0.0002)	(0.0013)
Jower	9.74					0.0013	-0.0007	0.0002	0.0012
	(2.11)					(0.0003)	(0.0001)	(0.0001)	(0.0005)
Rapeseed	1.54						0.0007	-0.00023	-0.0009
	(1.34)						(0.0001)	(0.0000)	(0.0003)
G. Nut	2.03							0.00052	0.00034
	1.17							(0.0001)	(0.00017)

Notes: OG-Other Grains. Diagnostic Statistics: R^2 of the system ranges from 0.5 to 0.85. Durbin-Watson statistics indicate no serious autocorrelation.

Price Transmission Equations

ln(Rice farm harvest price) = 0.71
(0.06)
+0.55 * ln(Thai 5% broken price, FOB Bangkok * exchange rate)
(0.05)

$R^2 = 0.94$

ln(Wheat farm harvest price) = -0.44
(0.12)
+0.76 * ln(U.S. hard red winter price, FOB Gulf * exchange rate)
(0.13)

$R^2 = 0.84$

ln(Maize farm harvest price) = 0.48
(0.15)
+0.65 * ln (U.S. #2 corn price, FOB Gulf * exchange rate)
(0.17)

$R^2 = 0.69$

ln(Sorghum farm harvest price) = -1.15
(0.13)
+0.88 * ln (Sorghum price, FOB Gulf * exchange rate)
(0.13)

$R^2 = 0.81$

ln(Other coarse grains farm harvest price) = -0.56
(0.17)
+0.79 * ln (Barley price, FOB Pacific * exchange rate)
(0.15)

$R^2 = 0.67$

ln(Rapeseed farm harvest price) = 0.48
(0.14)
0.72 * ln(Rapeseed price, CIF Rotterdam * exchange rate)
(0.32)

$R^2 = 0.61$

ln(Groundnut farm harvest price) = -1.42
(0.21)
+0.97 * ln(weighted average of soybean and rapeseed price * exchange rate)
(0.22)

$R^2 = 0.79$

ln(Soybean minimum support price) = -0.14
(0.09)
+0.74 * ln(Soybean price, FOB Gulf * exchange rate)
(0.07)

$R^2 = 0.93$

ln(Cotton farm harvest price) = 3.17
(0.65)
+0.31 * ln(Cotton A Index * exchange rate)
(0.11)

$R^2 = 0.87$

Note: Cotton A index is the average of the five lowest CIF Northern Europe quotes.

ln(Sugarcane farm harvest price) = 4.54
(1.1)
+0.11 * ln(Sugar price, FOB Caribbean * exchange rate)
(0.01)
0.25 * ln(time)
(0.08)

$R^2 = 0.89$

Assumptions for Exogenous Variables

Demand and supply projections depend upon assumptions about various exogenous variables such as population growth, real GDP growth, and world prices. Projections for these exogenous variables are from various sources. For example, marcoenonomic projections such as real GDP, GDP deflator, and exchange rate were collected from WEFA forecasts. Population projections are from United Nations (UN) 1996, medium variant projection. Representative world prices for various commodities are collected from 1998 Food and Agricultural Policy Research Institute (FAPRI) projections. Projections of many other variables such as area under irrigation, fertilizer application, and feeding efficiency are determined using historical trend.

Macro Assumptions

1. Population growth is projected to decline from 1.77 percent in 1993 to 1.413 percent in 2000 and declines further to 1.2 percent by 2010 (UN 1996, medium variant projection).

2. The growth rate of exchange rate and GDP deflator until 2001 are borrowed from WEFA Group projections and the 2001 growth rate is held constant for the remaining period.

3. Real GDP is projected to grow at an average annual rate of 6.2 percent between 1993 and 2000, 6 percent between 2000 and 2005, 5.8 percent for 2005 and 2010, and 5.8 percent for 2010 to 2015.

4. With declining population growth, this GDP growth is translated into a per capita real GDP growth rate of 4.7 percent for 1993 to 2000 and declining to 4.45 percent by 2015.

5. Private consumption is projected to decline from 68 percent to 65 percent of GDP by 2010 and further declines to 62 percent by 2015, which translates into decreasing growth rate per capita real expenditure from 4.1 percent in 1993 to 3.7 percent by 2015.

6. Due to urbanization, urban population is projected to grow from 26.2 percent in 1993 to 36.5 percent by 2010 and increases to 36.5 percent by 2015. Rapid urbanization causes the total rural population to start declining after 2014, even with population growth.

7. Urban and rural per capita expenditure is calculated using national average per capita expenditure from their population share and ratio of expenditures, using

   $E_r = E_a *(1-S_u)/PS_r$,

   where E_r = average per capita rural expenditure, E_a = average per capita expenditure, S_u = share of urban in total expenditure, and PS_r = population share of rural.

   The ratio of rural to urban expenditure is projected to decline from 62.3 percent to 54 percent by 2015. With these assumptions, urban per capita expenditures are projected to grow almost 1 percent higher than rural per capita expenditures.

8. Further inequality in income distribution is introduced in five income groups for the rural and urban populations. It is assumed that upper income groups will have a greater share of income growth.

Other Exogenous Assumptions

1. For each crop, the percentage of area under irrigation is assumed to increase according to a five-year moving average growth. For example, the percentage of wheat area under irrigation increases from 85 to 98 percent by 2015, whereas wheat area under high-yielding varieties increases from 88 to 100 percent by 2006 and remains 100 percent thereafter.

2. Fertilizer consumption per hectare is assumed to increase from 66.67 to 122 kilograms per hectare. Annual rainfall is assumed to be normal throughout the period.

3. World prices for major grains until 2006 are borrowed from FAPRI projections. After 2006, real world prices for grains are assumed to remain constant.

4. One percent annual feeding efficiency is assumed for the organized milk sector, whereas 1 percent annual increase in FCR is assumed for the unorganized sector. Similarly, for chicken and egg sectors, 1 percent annual feeding efficiency is assumed for both intensive and traditional production. In addition to the change in FCR, the composition of feed will also change over time. One percent annual increase in grain share is assumed across sectors. For example, the share of corn in intensive egg production to increase from 9 percent to 9.34 percent by 2030.

Demand and Supply Outlook for Grains

Strong income growth and urbanization are expected to significantly change the composition of the food basket. Average per capita consumption of cereals is projected to rise from 160 kg in 1993 to 167.8 kg by 2007 and starts declining after 2007, reaching 165.7 kg by 2015 (Figure 1). Rural per capita cereal consumption increases throughout the period, from 169 in 1993 to 189 kg by 2015, whereas urban per capita cereal consumption increases from 129.9 in 1993 to 131 kg by 1999 and then starts declining, reaching 124.15 kg by 2015 (Figure 1). Thus, until 2007 the increase in rural consumption is outweighed by a decline in urban consumption, causing the national average to rise. But after 2007, per capita decline in urban consumption is outweighed by an increase in rural per capita cereal consumption, resulting in a decline in the national average per capita cereal consumption.

Within the rural quintiles, most of the increase in per capita cereal consumption comes from the lower three quintiles. As expected, the largest increase is projected for quintile one from 155 to 183 kg, followed by quintile two, which increases from 160.5 to 189 kg (Figure 2). A modest increase is projected for quintiles four and five for the first few years, but consumption declines later in the period (Figure 2). Unlike rural groups, lower income groups (quintiles one to three) in the urban category are projected to increase their cereal consumption by a modest amount in the first few years of the projection but as incomes rise, the per capita cereal consumption is projected to decline for these groups. For example, per capita cereal consumption for quintile one increases from 123 kg in 1993 to 135.8 in 2010 and starts declining thereafter (Figure 3). It is interesting to note that per capita cereal consumption for quintiles four and five are projected to decline with rising income throughout the projection period (Figure 3).

Although average per capita cereal consumption does not seem to change much throughout the projection period, its composition changes significantly. Strong income growth and a shift in diets from rice and other coarse grain to wheat will drive per capita wheat consumption use steadily throughout the projection period, from 53.6 kg in 1993 to 69.9 kg by 2015 (Figure 4). Rising wheat consumption is mostly offset by declining per capita consumption of rice and other coarse grains such as maize, sorghum, barley, and millets. Per capita rice consumption increases by 1.5 kg from 1993 to the end of the century and declines by 6 kg from 2001 to 2015, resulting in a net decline of 4.5 kg for the period of 1993 to 2015 (Figure 4). Maize, sorghum, and other coarse grain consumption are projected to decline by more than 9 kg per capita during this period (Figure 4). Within the rural category, per capita wheat consumption is projected to rise significantly for all five income groups throughout the period (Figure 5), whereas a relatively modest increase in wheat consumption is projected for the lower income urban population (Figure 6). Per capita wheat consumption for higher income consumers even declines towards the later part of the period (Figure 6).

Another crucial change is consumption for maize and other coarse grains as animal feeds. Demand for maize for feed is projected to increase from 1.5 mmt in 1993 to 7 mmt by 2015 due to higher livestock production and from structural changes in the livestock industry. In this study, we have estimated feed use of grains by taking into account possible structural changes such as commercialization of production and changes in the feed ration in the livestock industry. It is also assumed that India will be self-sufficient in livestock production; that is, demand will be met by domestic production.

Unlike other developing countries, particularly China, India’s meat consumption is not likely to “explode” in the future because of high income growth. Rather, income growth is expected to cause a significant increase in milk and egg consumption. As shown in Figure 7, average per capita milk and eggs consumption are projected to more than double from 57 to 123 kg for milk and from 25 to 70 eggs. Unlike milk and egg consumption, meat consumption in India is extremely low and is expected to remain low compared with other developing countries primarily because of its large vegetarian population. Per capita chicken consumption, which is very low at 0.5 kg increases to 1.3 kg by 2015 (Figure 8). A similar increase is also expected for other meats such as goat, sheep, and beef. In order to meet this demand, India needs to produce

170 mmt milk and 61 billion eggs by 2015 compared with 1993 production of 65 mmt milk and 24 billion eggs.

Livestock production is converted into feed requirements using appropriate feed conversion factors and type of production technology. Currently, only 14 percent of total milk production comes from the organized sector (private and cooperative), whereas the remaining 86 percent of milk production comes from the unorganized sector (landless labor and small, medium, and large farmers). The organized sector is the primary user of grain as feed. In the future, milk production through the organized sector is likely to increase because of increased milk consumption and because of a recent change in government policies allowing large private investments to enter both milk production and processing. This organized sector is assumed to grow at an average of 1 to 2 percent per year. Similarly, higher chicken and egg consumption is likely to bring more commercialization to these sectors.

How will these translate into total demand requirements? As shown in Figure 9, demand for cereals is projected to grow from 166 mmt in 1993 to 240 mmt in 2015. This is a slowdown from historical trends, caused by a change in both diet structure and also due to continued slowing of population growth. Within cereals, the largest demand increase is for wheat, from 56 mmt in 1993 to 99 mmt in 2015 (a 76 percent increase). Driven by rapid growth in feed demand, total maize usage is also projected to almost double, from 9 mmt to 15.5 mmt during this period. Unlike wheat and maize, total demand growth for rice steadily declines throughout period and even becomes negative during the last few years. For example, rice demand increases from 78.5 mmt in 1993 to 101.5 mmt in 2013 and declines to 101.1 by 2015. This slowdown of rice demand may be attributed to changes in diet due to urbanization and also from slower population growth. But the real question is whether India will be able to produce enough grain to meet domestic demand with limited land availability and declining productivity.

Supply Outlook for Grains

In India, the total physical area sown for crops is not expected to increase significantly during our projection period. Most of the increase in sown area will come from increasing cropping intensity. As shown in Figure 10, cropping intensity is projected to increase from 126.7 percent in 1993 to 140.9 percent by 2015, causing the gross sown area to rise from 178.5 mha to 204.6 mha. But most of the increase in sown area is expected to go into horticultural and other perennial cash crops. Thus, out of a 26 mha increase in total sown area, less than 50 percent is expected to be for crop production (an increase of approximately 12 mha, from 151 to 163 mha).

Area allocated among various crops is based on relative gross returns for the crop. Gross returns for individual crops are calculated by multiplying expected price with yield. Within crops, oilseeds such as soybeans, rapeseed, and groundnuts are the primary recipients of additional land, with a modest increase projected for traditional crops like wheat, rice, and corn. Among traditional crops, wheat area is projected to increase from 25.4 to 27.4 mha followed by maize with increases from 6.1 to 6.4 mha.

Even with 2 mha of additional area, wheat production is unlikely to meet rising domestic demand. During our projection period, wheat production increases from 57.2 to 89.8 mmt, whereas domestic consumption increases from 56 to 99 mmt, causing a deficit of approximately 9 mmt (Figure 11). One of the main factors contributing to the wheat deficit is slower yield growth. The growth rate of production has significantly declined since the beginning of the 1990s. For example, food production increased by 3.74 percent annually during the 1980s as compared with 2.03 percent in the first seven years of the 1990s (Brahmandanda 1997). In the 1970s and 1980s, yield growth has resulted from three primary factors: massive investments in irrigation, heavy fertilizer consumption, and adoption of high-yielding varieties. The recent decline in grain yield growth has been attributed to declining growth rate of irrigation area and fertilizer use. This declining trend in yield growth is unlikely to reverse in the next decade because input subsidies are being reduced to reduce the budget deficit. GATT and WTO commitments and wheat area under high-yielding varieties are likely to reach 100 percent by 2005. In addition, wheat area under irrigation is also fast approaching 100 percent. Thus, the declining trend in wheat productivity may be reversed for high-yielding varietal innovations such as Roundup-ready soybeans.

Unlike wheat, rice production, which increases from 80.3 to 133 mmt by 2015, is likely to keep pace with increasing consumption from 78.5 to 128 mmt (Figure 12), even with very slow yield growth. Rice yield in India is only 75 percent of the world average and as low as 45 percent of China’s (Brahmananda 1997). Borlaug (1993) observed that low rice productivity in India is caused by agronomic factors. Long-term growth rate in rice productivity in the post-Green Revolution (2.3 percent) is marginally higher than in the pre-Green Revolution (2.25 percent). Stagnation of rice productivity growth may be from 50 percent of India’s rice area being located in the chronically low productivity states of Assam, Biharm Madhya Pradesh, Maharastra, and Orissa, with yield ranging from 60 to 84 percent of the national average. A recent study by Majhi (1996) determined that, without appropriate production technology for these resource-poor regions and adverse climates, it is unlikely that there will be a quantum leap in rice yield in the next decade. Even with lower rice productivity in the future, India still remains a significant rice exporter, although increased exports will be limited until 2005 due to rising consumption. But as a per capita consumption declines because of income growth and urbanization, India's export potential is likely to increase.

Similar to wheat, corn production is not likely to keep pace with rising domestic consumption. But increased consumption comes from feed rather than from food demand. In fact, food use of corn declines throughout this period because of declining per capita consumption. Feed utilization of corn increases approximately fourfold, from 1.5 to 5.6 mmt by 2015, due to higher animal and livestock products, particularly eggs, milk, and broilers. Structural changes in the livestock sector such as commercialization and feeding efficiency, also increase feed utilization of corn (Figure 13). Increased production, from 9.8 to 13.8 mmt due to higher area and yield, falls short of consumption growth, which grows from 9.5 to 15.2 mmt, resulting in a deficit of 1.5 mmt by 2006 (Figure 14). In addition to corn, India's growing livestock industry is likely to increase feed utilization of sorghum, millets, and other coarse grains. For example, feed utilization of sorghum keeps total consumption close to production. India is also likely to stay self-sufficient in other coarse grain such as barley and millets. For these grains, increased feed consumption in combination with declining good consumption stay close to production increases, which come mostly through yield growth.

Overall, India remains close to self-sufficient in cereals until the end of the century, with rice exports more or less offsetting wheat and corn imports. But in the beginning of the next century, wheat and corn imports are likely to exceed rice exports because of higher demand in the food and feed sectors, making India a net importer of cereals. India is projected to be a net importer of cereals, about 8 mmt, by 2015.

Conclusions

This study provides demand and supply projections for major feed grains in India for 1993 to 2015. Demand is estimated using household expenditure survey data and is differentiated by urban and rural and five different income groups within each region. Per capita wheat consumption is projected to increase throughout the period due to income growth and urbanization. Unlike wheat, per capita rice consumption is likely to increase for the next few years but then declines as incomes rise. For other grains such as corn and sorghum, total demand increases because of higher feed use. Production is estimated by estimating area and yield. Area is allocated among various crops according to the returns for own and substitutes and considering total physical land availability and cropping intensity. As expected, total physical land will remain more or less flat in the next two decades. But net cropped area is projected to increase through higher cropping intensity. More than 70 percent of additional area is likely to switch to horticultural and permanent crops. Among crops, oilseeds such as soybeans, rapeseed, and groundnuts account for most of the remaining additional area.

A comparison of production and consumption of grain indicates that Indian wheat consumption is likely to exceed production. The difference between production and consumption is projected to become wider. India is also likely to be an importer of corn over the longer run. Unlike wheat and corn production, Indian rice production exceeds consumption throughout the period. Overall, India is expected to be self-sufficient in cereals until the beginning of the next century, but then cereal consumption exceeds production, making India a significant net importer of cereals, particularly wheat and corn.

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