

Changing Consumption Patterns of India: Implications on Future Food Demand

¹Upali A. Amarasinghe and ²Om Prakash Singh

¹International Water Management Institute, New Delhi, India

²Agricultural University, Varanasi, Uttar Pradesh, India

Introduction

Food grains dominate the vegetarian centered diet of the Indian people, although the composition varies across different regions. Grains provided 65 % of the calorie supply in 2000, and this varied from 60 % in the north to 74 % in the south. Rice is the main food grain in the south and the east, followed by wheat in the east and coarse cereals in the south; wheat is the principal food grain in the north followed by rice; and wheat comprises half of the grain consumption in the west, followed equally by rice and other coarse cereals. The non-grain food crops and animal products provided 27 % and 8 % of the remaining calorie supply in 2000. Due to cultural and religious reasons, the meat consumption in India is very low, and much of the animal product calorie supply at present is from milk and milk products. Milk consumption also varies significantly from 101 liters per person per year in the north to 26 liters in the south.

However, recent trends show shifts in food consumption patterns, with increasing consumption in non-grain food crops and animal products. The FAOSTAT data (FAO 2005) show per capita grain consumption has been decreasing since the 1980s. This decline is due to various factors, including income growth, urbanization and associated changes in life styles, changes in relative prices and the availability of non-grain food, etc. The National Sample Survey Organization (NSSO) survey results show that the average monthly per capita cereal consumption in the urban areas of India has decreased from 11.2 kg in 1973-1974 to 10.6 kg in 1993-1994. The corresponding decline in the rural areas is 15.3 kg and 13.4 kg, respectively. Within the grain products, there is a shift from coarse cereals to superior cereals such as rice and wheat (Viswanathan 2001). Nilkanth Rath 2003 has suggested that the per capita grain consumption will further decrease due to the reduction in physical labor requirement in rural areas. It is likely that these changing patterns will accelerate in the future with increasing income and urbanizations. The purpose of this paper is to capture these changing consumption patterns and assess their implication on India's food demand.

Several studies in the past have also projected India's food grain demand for 2020 (Bhalla et al. 1999; IWMI 2000; Kumar 1998; Rosegrant et al. 1995; Radhakrishna and Reddy 2004). These studies have, in varying degrees, accounted for the emerging trends of increasing animal product consumption and the resulting feed demand. However, most of the studies have

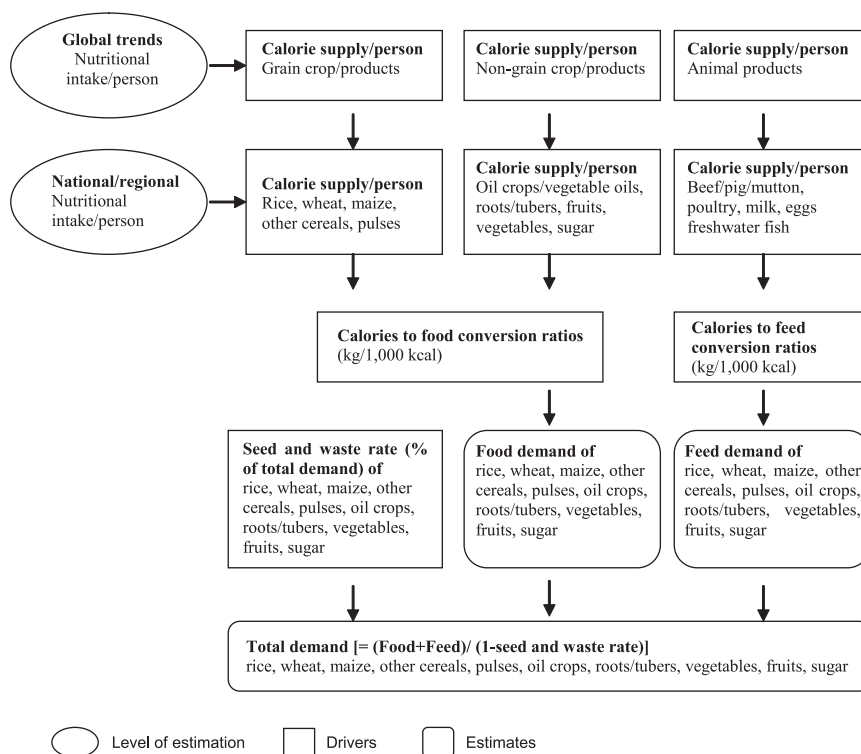
concentrated only on the grain demand. Based on the spatial and temporal trends between 1987 and 1988 and between 1993 and 1994, Dyson and Hanchate 2000 have projected the grain and non-grain crop demand at the state level to 2020.

This study extends the projections of crop demand to 2050, by using the global, national and regional level changes of consumption patterns in recent times. The rest of the paper is divided into four sections. The next section explains the assumption and the methodology adopted in this paper. The third section presents the projections to 2025 and 2050, and compares them with the National Commission of Integrated Water Resources Development and other projection results (GOI 1999). The fourth section presents the implication of the increased grain demand projections on the water demand. We conclude the paper by discussing the policy implications and further research requirements.

Methodology, Data and Assumptions

The study assesses the demand for 12 major crops or crop categories (called only ‘crops’ hereafter). They include the grain crops: rice (milled equivalent), wheat, maize, other cereals (such as jowar, bajra, ragi, barley, millet etc.); and pulses and the non-grain crops: oil crops (including vegetable oils as oil crop equivalent), roots and tubers (dry equivalent), vegetables, fruits and sugar. FAOSTAT food balance sheets show that these crops accounted for 99 % of

Figure 1. Crop demand estimation for India.



the nutritional supply in the daily diets between 1991 and 2001, directly through food and indirectly through feed for the livestock (FAO 2005). Hence they were selected for the demand projection in this study. We also keep an allocation for seeds and waste.

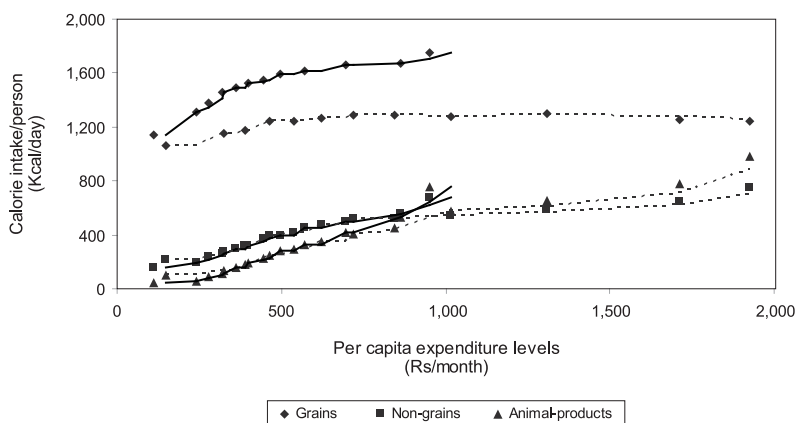
Figure 1 shows our approach to crop demand estimation. First we project the nutritional intake of grain, non-grain and animal product food categories using the global trends. Second, we assess the level of consumption of different crops or animal products that provide the projected calorie supply in the Indian context. Here we account for the regional variations of consumption patterns in India. Details of these are discussed next.

Nutritional Supply

Income and urbanization are two of the key drivers of changing nutritional intake patterns. In general, changing consumption patterns exist extensively in the middle - to high-income countries. Global consumption patterns show that, while food grains dominate the diets of the low-income categories, non-grain food products provide more than two-thirds of the daily calorie needs in the developing countries (FAOSTAT data, FAO 2005). As income and urbanization increases, the non-grain crops and animal product consumption increases. A significant diversification of diets occurs when people move away from the low-income to middle - and high-income categories. Differences of consumption pattern across different expenditure classes in India show high-income groups consume more non-grain crops and animal products.

We use the global consumption pattern to assess the trends of future calorie intake of the three food categories. Our approach is similar to the study by Knudsen and Scandizzo 1982, except that we use a sample of low- to middle-income countries to represent the variation of income. As India would only become an upper-middle-income country by 2050, we restricted our analysis to a sample of countries with GDP/person < US\$10,000, and estimate the econometric relationship of the three calorie intakes against the GDP and urban population (Table 1). The calorie supply from grain products is very much regional or country-specific,

Figure 2. Calorie intake in rural and urban areas in India from 1999-2000.



Source: NSSO survey 55th round

Note: Solid and dash lines indicate the trends in rural and urban areas, respectively.

Table 1. Estimated regression equations.

Variables	Ln (CAL_i^G)		Ln (CAL_i^{NG})		Ln (CAL_i^{AP})	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Constants						
Cluster 1 - α_{01}	6.85 ^a	0.026	6.355 ^a	0.116	4.30 ^a	0.208
Cluster 2 - α_{02}	0.204 ^a	0.020	-0.115	0.085	-0.026	0.153
Cluster 3 - α_{03}	0.390 ^a	0.021	-0.206 ^a	-0.092	0.172	0.165
Cluster 4 - α_{04}	0.636 ^a	0.022	-0.432 ^a	-0.096	0.013	0.176
GDP						
α_1	-0.000002	-0.000002	0.000478 ^a	0.002	0.0012 ^a	0.0001
GDP– middle income						
α_2	-	-	-0.000476 ^a	0.0001	-0.0011 ^a	0.0001
% Urban population						
α_3	-0.0035	.002	0.00430 ^a	0.002	0.0094 ^a	0.0040
R ²	0.92		0.53		0.59	

Note: a- statistically significant at 0.05 level

and primarily depends on taste. This is evident in the statistically significant coefficients of the clusters with varying levels of grain consumption. Clusters 1 to 4 represents four homogeneous groups with grain consumption. Average daily intake of calories from grains in cluster 1 to 4 is 901, 1,130, 1,363, and 1,769, respectively.

At present, India's grain consumption is very high. On average daily calorie supply per person is 1,579 kcal. Therefore, income in India is not a significant driver any more of the grain consumption (Table 2). The negative but low elasticity of urbanization (Table 2) show that the changing rural-urban demographic patterns gradually contribute to the declining grain consumption. In fact, urbanization is contributing to about 97 % of the decline in the grain calorie supply in India.

With increasing income and urbanization, calorie supply of non-grain crops and animal products increases, but the rate of growth decreases in the middle-income countries. The elasticity estimates for India, show that while income growth contributes to a significant part

Table 2. Elasticity of calorie demand with respect to GDP and urban population growth.

Sources of growth	Elasticity in 2000 (GDP= US\$463, PCTUP=28 %)			Elasticity in 2025 (GDP= US\$1,765, PCUP=38 %)		
	Grains	Non-grains	Animal products	Grains	Non-grains	Animal products
GDP growth	-0.001	0.22	0.52	-0.004	0.11	0.32
Urbanization	-.097	0.12	0.26	-.133	0.16	0.36

(85 % in 2000) of the non-grain calorie supply change between 2000 and 2025, urbanization also contributes to the majority of this change after 2025. However, the income growth continued to be a significant factor of animal product calorie supply growth in both periods.

To assess the extent of the diversification of consumption patterns of different crops, we project the calorie intake of grains, non-grain crops and animal products in the Indian diet. For this projection we use global trends of energy intake of different food categories with respect to the changes in income and urbanization. We project India's calorie intake of grains, non-grain crops and animal products, with respect to the changes in income and urbanization from the levels of the base year 2000. The projections of calorie supply in 2025 and 2050 are given in Table 3.

Our projections show that non-grain crop products will dominate the Indian diet by 2050. The total calorie supply is projected to further increase, 15 % by 2025, and another 8 % by 2050. Almost the entire increase in calorie intake after 2025 is due to the increased consumption of non-grain crops and animal products. Our projections show a slight decline of the calorie supply from grains (9 %) by 2050, but significant increases in the non-grain crops (75 %) and animal products (144 %). The composition of calories supply from grain, non-grain and animal products changes from 63, 29 and 8 % in 2000 to 55, 33 and 12 %, respectively, by 2025 and 48, 36 and 16 %, respectively, by 2050.

Table 3. Calorie supply projections to 2025/2050 for India.

Year	GDP (person/year)	Urban population (% of total)	Calorie supply/person/day			
			Grains	Non-grains	Animal products	Total
			kcal	kcal	kcal	kcal
1990	313	25	1,640	562	163	2,365
2000	463	27	1,579	673	183	2,435
2025	1,765	37	1,520	912	343	2,775
2050	6,731	53	1,440	1,083	477	3,000

Source: Mamhood and Kundu 2006 (for urban population projection)

Note: GDP in 1995 in constant \$ (source for 1990 and 2000 is WRI 2005). We assume a 5.5 % annual growth rate for 2025 and 2050 projections.

Composition of Nutritional Intake of Grains

The composition of the diet in different food categories depends on the taste and preference of the people, and as mentioned before, it varies significantly across regions. Thus, we need to take these differences into account in projecting individual crop demands. In India, there is a declining trend of consumption of coarse cereals. In 2000, rice and wheat contributed to most of the calorie intake (47 % and 31 %) from grains, while maize, other cereals and pulses contributed to 5, 9 and 7 %, respectively, of the calorie intake of grains. Dyson and Hanchate 2000, using the trends between 1987 and 1988 and 1993-1994 National Sample Survey Organization (NSSO) rounds observed that the per capita cereal consumption has declined in all states except in Kerala and West Bengal. The consumption of rice and wheat remains

stable and decreasing coarse grain consumption was the major contributor to the cereal consumption decline.

Cereal consumption has further declined between 1993 and 1994 and 1999-2000 NSSO rounds, but the rate of decline had also decreased significantly. The cereal consumption/person/day before and after 1993-1994 NSSO rounds has declined by 1.19 and 0.74 % annually in the rural areas, and by 0.91 and 0.24 % in the urban areas. Within the cereal category, wheat consumption has shown no significant change (Table 4). However, a declining trend in rice consumption, especially in the rural areas, is seen in the post-1993-1994 NSSO rounds of surveys. The consumption of pulses remains unchanged at the 1987 level, though it had decreased before 1993-1994. In the urban areas, the consumption of other cereals has also declined further, but at a much slower rate than earlier. A notable trend, however, is the increasing rate of decline of rice consumption in the rural areas. Rural rice consumption per person has decreased 0.5 % annually after the 1993-1994 NSSO rounds against only a 0.05 % decline before the 1993-1994 NSSO rounds.

Table 4. Consumption/ person of grain crops in India.

Year	Rice		Wheat		Maize		Other cereals		Pulses	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Past trends (annual growth rates, %)										
1987-1993	-0.05	-0.42	-0.60	0.27	-4.97	-6.78	-4.97	-4.97	-2.40	-1.62
1993-1999	-0.50	-0.10	0.50	0.04	-5.03	-2.77	-5.03	-2.77	4.37	4.45
Projected annual growth (%)										
2000-2025	-0.04	-0.01	0.00	0.00	-0.40	-0.22	-0.40	-0.22	0.00	0.00
2000-2050	-0.11	-0.02	0.00	0.00	-1.06	-0.59	-1.06	-0.59	0.00	0.00
Consumption/person/month in India (kg)										
2000	6.78	5.15	4.80	4.89	1.10	0.09	1.72	0.67	0.93	1.04
2025	6.71	5.14	4.80	4.89	0.99	0.09	1.55	0.63	0.93	1.04
2050	6.43	5.10	4.80	4.89	0.64	0.07	1.01	0.50	0.93	1.04

Sources: The trends are estimated from the data of NSSO rounds in 1987-1988, 1993-1994, and 1999-2000 (NSSO 1996, 2001). The 2025 and 2050 projections are authors' estimates.

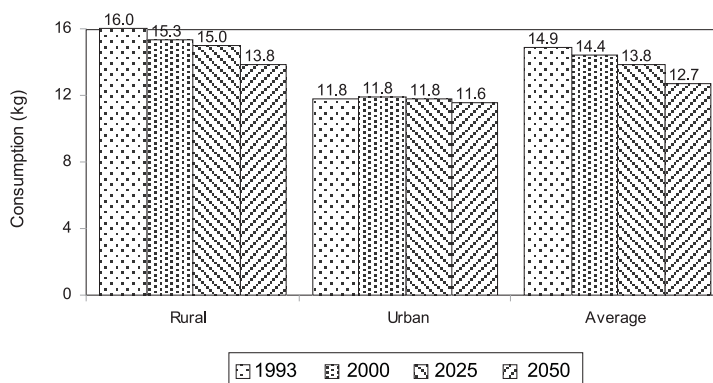
We project that the composition of grains in the diet will further change, but will soon reach a steady state in both rural and urban areas. As in Dyson and Hanchate,¹ we use recent trends to project future demand, but subject to the restriction that the total calorie supply/

¹ Dyson and Hanchate 2000 project the cereal consumption/person/month in the rural and urban sectors to decrease from 15.1 and 12.3 kg in 1993-1994 to 12.7 and 10.9 kg by 2020. Other studies based on expenditure elasticity have projected an increase in per capita cereal consumption by 2020 (Bhalla et al. 1999). However, many argue (Dyson and Hanchate 2000; Bansil 1995) that due to the complex nature of taste and preferences, and changes in life styles across states and across income classes, the estimated elasticity may also change in the future.

person/day of grain products will be 1,520 kcal in 2025 and 1,440 kcal in 2050 (Table 4). As the long-term trends show no significant change, we assume that the per capita consumption of wheat and pulses remains the same in the rural and urban areas. The adjusted growth rates of per capita consumption are given in Table 5. The rural rice consumption per person is projected to decrease from 6.78 kg per month in 2000 to 6.43 kg per month by 2050.

The final projections of grain consumption at the national level depend not only on the level of per capita consumption in rural and urban areas but also on the population change. A recent study projects that India's total population will increase from 1,027 million in 2001 to 1,383 million in 2025, and to 1,585 million by 2050 (Mahmood and Kundu 2006). And the rural population, as a share of total population will decrease from 72 % in 2000, to 63 and 47 % by 2025 and 2050, respectively. As a result, the rural-urban differential of the consumption and increasing urban population, average grain consumption/person/month declines at a faster rate than in rural and urban areas (Figure 2). The composition of calorie supply of rice, wheat, maize, and other cereals and pulses will change from 47, 31, 5, 9 and 7 % in 2000 to 48, 33, 4, 8, 7 %, respectively in 2025 and 49, 35, 3, 5 and 8 %, respectively, by 2050.

Figure 2. Grain consumption/person/month.



Sources: 1993, 2000 data from NSSO rounds. 2025 and 2050 are authors estimates.

Composition of Calorie Supply of Non-grains

The consumption of non-grain crops such as fruits, vegetables and edible oils, will prominently feature in the future Indian diet. Kanchan Chopra 2003 and Dyson and Hanchate 2000 have noted that fruit and vegetable consumption will increase significantly by 2020. Our projections of the nutritional intake indeed, show that the contribution of the non-grain crops to the total calorie supply is expected to increase from 29 % in 2000 to 33 and 37 % by 2025 and 2050, respectively. How is the composition of non-grain crops changing?

The oil crops (including edible oil) and sugar products provided 79 % of the calorie supply of non-grain crop products (Table 5). While the contribution of oil crops to the total calorie supply has increased over the years (34 % in 1980 to 42 % in 2000), the contribution from sugar products has decreased from 43 % to 37 % over the same time period. The contribution of roots and tubers, vegetables and fruits shows no major changes (9 %, 7 % and 7 % in 1980 to 7 %, 7 % and 8 % in 2000). Where the per person consumption is

concerned, fruits, vegetables and oil crops have shown a substantial annual growth in the last decade.

Indeed, the calorie supply from oil crops and sugar in India (528 kcal/person), compared with other developing countries (273 kcal/person), is significantly higher now. But this is much lower than the calorie supply in the developed countries (871 kcal/person). Fruit and vegetable consumption, which is highly income-elastic, provides 96 kcal/person, and this is much lower compared with that in other developing countries (170 kcal/person). However, with increasing income and urbanization, fruit and vegetable consumption is projected to increase rapidly. We use this information to project the composition of calorie supply of non-grain crops in the future.

Table 5. Calorie supply from non-grain crops.

Year	Total	Oil crops	Roots and tubers	Vegetables	Fruits	Sugar
Calorie supply from non-grain crops (kcal/person/day)						
1980	449	152 (34)	41 (9)	32 (7)	31 (7)	193 (43)
1990	526	195 (37)	40 (8)	35 (7)	34 (7)	221 (42)
2000	673	281 (42)	49 (7)	45 (7)	51 (8)	247 (37)
2025	912	442 (49)	66 (7)	67 (7)	63 (7)	274 (30)
2050	1,083	500 (46)	105(10)	75 (7)	87 (8)	316 (29)
Annual growth (%)						
1980-1990	1.7	2.5	-0.3	0.9	1.0	1.4
1990-2000	2.5	3.7	2.0	2.4	4.1	1.1
2000-2025	1.2	2.2	0.9	1.6	1.9	0.6
2000-2050	0.9	1.3	1.4	1.0	1.6	0.6

Sources: 1980-2000 data are from FAO 2005. The 2025, 2050 data are the authors' projections.

Note: Numbers within parentheses show the percentage of the total calorie supply.

As in the estimation of grain crop consumption, the annual growth rates of the consumption per person between the 1993-1994 and 1999-2000 NSSO rounds are used for projections of non-grain crops (Table 6). First, we project per person rural and urban consumption demand. The state-level consumptions are projected according to the differences of state-level growth rates. However, two adjustments on the growth rates are necessary before we make future projections. First, with annual growth rates from 1993-1994 and 1999-2000, NSSO rounds, the total calorie supply projection from the non-grain products is much higher than the projected total in Table 5. Therefore, we adjust the annual growth rates of rural and urban sectors so that the total calorie supply per person of non-grain products will be 940 kcal in 2025 and 1,140 kcal in 2050. Second, even with this adjustment, the calorie supplies of oil crops and vegetables in 2050 are unrealistically high, and they are even higher than the levels of the highest-consuming countries at present. Therefore, we set a ceiling for the per capita consumption of these crops, 500 kcal for oil crops, and 75 kcal for vegetables by 2050, a level comparable to the highest consumption in the developing world.

The projections of the per capita consumption of vegetables and fruits in our study for 2050 are even lower than those of the Dyson and Hanchate 2000 for 2020. They project that the rural and urban vegetable consumption per person increases to 162 and 140 kg/year by 2020, respectively, and that the fruit consumption increases to 39 and 78 kg/year by 2020, respectively. The calorie supply from this level of vegetable and fruit consumption (170 kcal/person) is even higher than the present-day calorie supply of the developed countries. The growth assumptions in our study, however, are less rigid, and we believe they will result in more realistic projections by 2025 and 2050.

Table 6. Consumption of non-grain crops in India.

Year	Oil cops		Roots and tubers		Vegetables		Fruits		Sugar	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Past trends (annual growth rates (%))										
1987-1988	3.9	3.3	1.4	0.3	3.9	0.2	1.6	1.9	-1.3	-0.2
1993-1999	6.6	5.9	5.1	3.7	6.1	5.8	2.0	1.8	1.7	0.7
Projected annual growth (%)										
2000-25	1.7	1.5	1.3	1.0	1.6	1.5	0.5	0.5	0.4	0.2
2000-50	1.0	0.9	1.8	1.3	1.0	0.9	0.7	0.7	0.6	0.2
Consumption/person/year in India (kg)										
2000	37	53	6	5	68	72	31	64	25	29
2025	57	77	8	6	100	105	35	72	27	30
2050	62	83	15	10	111	116	44	89	33	32

Food Demand

The total food demand projections for 2025 and 2050 are given in Table 7. We use the state-level population projections of Mahmood and Kundu 2006 for estimating the total food demand. According to this demographic projection, the rural population will increase from 729 million in 2000 to 879 million in 2025 and then decrease to 776 million by 2050. The urban population will increase from 278 million in 2000 to 510 million in 2025 and to 810 million by 2050. Overall,

Table 7. Total food demand projections in 2025 and 2050.

Food demand (Mmt)											
Year	Grain	Rice	Wheat	Maize	Other cereals	Pulses	Oilcrops	Roots and tubers	Vegetables	Fruits	Sugar
1990											
2000	173	76	58	10	17	12	42	6	70	40	26
2025	230	102	81	11	20	16	89	11	142	67	39
2050	241	109	92	7	14	19	115	19	180	106	52

Source: 1990 and 2000 data from FAOSTST (FAO 2005). Figures for 2025 and 2050 are authors' estimates.

the total population will reach the peak of about 1,580 million by 2050 and will start to decline thereafter. More than half (53 %) the total population will be in urban areas by 2050.

Feed Demand

At present, India's feed grain demand is very low due to the low level of animal product consumption. In 2000, animal products contributed to only 7 % of the daily calorie supply. And milk and milk products provided the bulk (91 %) of this calorie supply. Much of the feed demand for producing this calorie supply at present is met through open grazing, crop residues, food waste, oil cakes, etc. The total feed grain use in 2000 was only 8 Mmt, which is only 4 % of the total grain use. However, feed demand is expected to increase much faster with increasing animal products in the diet.

Our nutritional intake projections show that the animal product calorie supply will increase 89 % between 2000 and 2025; and further 54 % between 2025 and 2050. Recent trends show that the consumption of poultry products, eggs and freshwater fish is rapidly increasing (Table 8). Due, mainly, to religious and cultural reasons, meat consumption, especially beef and pork, is very low and has posted no significant growth in the last few decades. Milk consumption, 98 kg/person/year, which is relatively high compared to that in developing countries, increased at 0.8 annually in the 1990s.

If recent trends are indications of the future, then milk products will still dominate the animal product consumption. The share of poultry products will also increase substantially. We use the trends between 1993 and 1994 and 1999-2000 NSSO rounds for projecting the future demand of animal products. And we subject the projections to the constraint that the total calorie supply from the animal products does not exceed the projections of 341 and 478 kcal/

Table 8. Consumption of animal products in India.

Year	Beef/pork/mutton		Milk products		Poultry products		Eggs		Freshwater fish	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Past trends (annual growth rates (%))										
1987-1988	1.8	-2.7	3.4	2.3	0.0	7.0	3.5	0.6	2.0	2.7
1993-1999	1.6	1.0	-0.5	0.8	12.2	12.2	9.3	5.7	2.6	1.6
Projected annual growth (%)										
2000-2025	1.5	0.9	0.7 ¹	0.7	11.4	11.4	8.7	5.3	2.4	1.5
2000-2050	1.1	0.6	0.5 ¹	0.5	8.2	8.2	6.3	3.8	1.8	1.1
Consumption/person/month (kg)										
2000	0.28	0.47	4.81	7.33	0.07	0.13	0.09	0.18	0.23	0.24
2025	0.46	0.63	6.14	9.36	0.42	0.85	1.56	1.07	0.53	0.40
2050	0.53	0.69	6.59	10.04	0.74	1.48	3.74	1.82	0.68	0.47

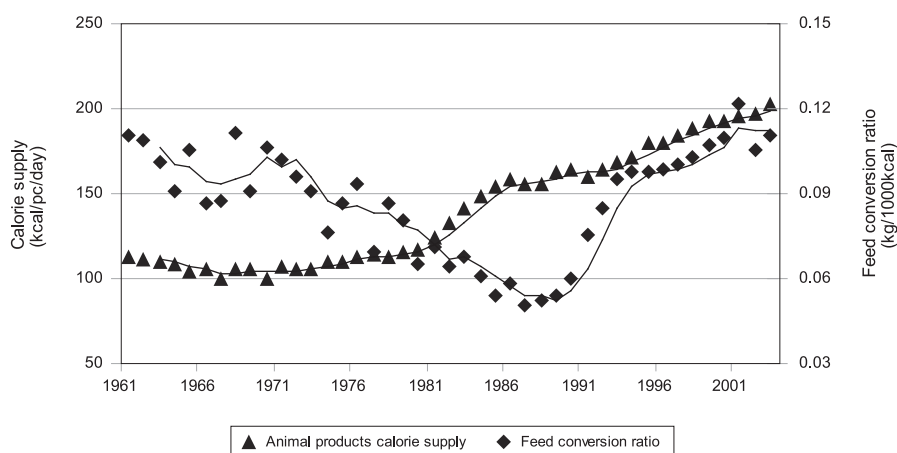
Source: Past trends estimated from the data of NSSO rounds in 1887-1888, 1993-1994, and 1999-2000 reports (NSSO 1996, 2006). The consumption data of NSSO 1999-2000 are adjusted to match FAOSTAT totals of 2000. The projections are authors' estimates.

Note: ¹ The growth of milk consumption in the rural areas during 1993-1990 was negative. We assume that it would increase at the same rate as in the urban areas in the future.

person/day in 2025 and 2050, respectively. The projections show that milk products will still contribute to 66 % of the calorie supply by 2050. But the share of calorie supply from poultry products will increase from only 1 % in 2000 to 20 % by 2050. Since poultry farming mainly operates at a commercial level, the consumption increase will have a substantial impact on the feed grain demand.

This paper uses feed conversion ratio (FCR) to estimate the feed grain demand. FAOSTAT data show that the feed conversion ratio of grain was decreasing until the late 1980s (Figure 3). During this period, the growth of feed use has not matched the pace of increasing animal product calorie supply. However, with increasing use of grains, especially maize, for livestock, the FCR started moving upwards since the late 1980s. Between 1988 and 1995, the FCR increased at 9.3 % annually. Over this period, the calorie supply from animal products increased at 1.6 %, while the feed grain use increased at 13.2 %. The growth of FCR between 1995 and 2002 was 1.9 %. During this period, the calorie supply of animal products increased annually at 1.6 % while feed grain use increased at 5.3 % annually.

Figure 3. Growth of animal product calorie supply per person and feed conversion ratio of grains.



We use the growth rates of feed conversion ratios between 1995 and 2002 to project feed use for 2025 and 2050. First, we project the feed conversion ratios of grains. The growth rate of feed grain conversion ratio is adjusted according to the growth rates of the animal product calorie supply. The animal product calorie supply is projected to increase by 2.2 and 1.7 % in the periods 2000-2025 and 2000-2050, respectively, while the feed conversion ratios are projected to increase by 2.7 and 2.0 % in the corresponding periods. The projected FCR of grains by 2025 is 0.37 kg/1,000 kcal, and is slightly higher than the FCR of China in 2000 (0.34 kg/1,000 kcal), but still much lower than the developed countries (0.74 kg/1,000 kcal).

With the projected feed grain conversion ratios, the feed grain demand will increase 4.6 times by 2025; and 13.7 times by 2050, from the level of 8 Mmt in 2000 (Table 9). Next we estimate the individual grain crop demand. Here we adjusted the growth rates of feed conversion ratios of individual crops by a similar factor subject to the constraint that the total feed demand of individual crops is equal to the projected feed grain demand.

Table 9. Feed consumption.

Factors	Grains	Rice	Wheat	Maize	Other cereals	Pulses	Oil crops	Roots and tubers	Vegetables	Fruits	Sugar
Feed conversion ratios in kg/1,000 kcal											
1995	0.098	0.005	0.012	0.054	0.007	0.020	0.013	0.000	0.000	0.000	0.007
2000	0.113	0.004	0.011	0.077	0.005	0.015	0.010	0.000	0.000	0.000	0.005
Annual growth rates of feed conversion ratios (%)											
1995-2002	2.0	-2.6	-1.7	5.4	-4.2	-4.2	-3.2	0.0	0.0	0.0	-2.7
2000-2025	2.7	-1.9	-1.3	4.0	-3.1	-3.2	-2.4	0.0	0.0	0.0	-2.7
2000-2050	2.1	-1.4	-1.0	3.0	-2.3	-2.3	-1.8	0.0	0.0	0.0	-2.7
Feed demand (Mmt)											
2000	8.1	0.4	0.9	5.3	0.4	1.2	0.6	0	0	0	0.4
2025	37.5	0.5	1.5	33.8	0.4	1.2	0.8	0	0	0	0.3
2050	111.2	0.6	1.8	107.4	0.3	1.0	0.8	0	0	0	0.1

Source: Authors' estimates are based on FAOSTAT data.

The majority of the feed demand increase is for maize. According to estimates of the United States Department of Agriculture (USDA), 42 % of the maize production at present is for feed in the poultry sector. And with increasing consumption of poultry products, maize demand for feed will increase rapidly (Landes et al. 2004). Our projection shows that the consumption of poultry meat and eggs is projected to increase at 9 % and 5 % annually over the next 50 years. Poultry production of this magnitude can only be sustained under commercial farming and much of the feed demand in this sector will be met from maize. And we project that the maize demand for feed will increase 6 % annually over the next 50 years.

Total Crop Demand

The rates of seed, waste and other uses (i.e., as a percent of total domestic use) of many crops have slightly decreased over the last decade (Table 10). However, the waste of maize, roots and tubers and fruits is still substantial. With improved post-harvest technologies and storage facilities, and with increased transport facilities and marketing in the rural areas, waste rates of all crops are expected to decline. We use the trends between 1990 and 2000 to project future seed and waste rates subject to the following constraints. If the projected values of the combined seed and waste rates fall below the seed rates in 2000, then we assume the seed rates in 2000 for the projection. Second, if the growth rates of seeds and waste rates show an increasing trend in the 1980s and 1990s, then we assume the seed and waste rates in 2000 for the projection.

The projected seed and waste rates of all crops, except oil crops, roots and tubers, and fruits, are lower according to our projections. The share of the waste in the rates of seed, waste and other uses of roots and tubers, and fruits is high and has been increasing in the past. But, better storage and transport and marketing facilities would have a significant impact in reducing waste in these two crops. However, the information available now is not sufficient to assess the extent of the waste reduction of these crops. So we assume the rates in 2000 for

future projections. With the projected rates of seeds, waste and other uses, we are now set to estimate the total crop demand (last three rows of Table 11).

The total grain demand is projected to increase by 45 % and 88 % in 2025 and 2050, respectively. The increasing maize demand, especially for feed, contributes to much of the total grain demand increase. The total grain demand is projected to increase by 176 Mmt between 2000 and 2050. The maize demand increase, of 101 Mmt, contributes to 57 % of the additional grain demand. Although the rice and wheat demand increases are the same (35 Mmt), the level of increase of wheat demand over the 2000 consumption level is significantly higher. Another important observation is the increasing demand of non-grain crop products. The demand for non-grain crops will more than double over the next 50 years.

Table 10. Seed and waste rates and total crop demand.

Factors	Grains	Rice	Wheat	Maize	Other cereals	Pulses	Oil crops	Roots and tubers	Vegetables	Fruits	Sugar
Seeds and waste rates of total consumption (%)											
1980	10.2	8.3	12.8	19.6	9.4	10.2	18.9	16.4	7.2	12.9	0.02
1990	10.1	7.6	12.1	19.3	9.4	9.0	11.3	18.9	7.0	13.2	0.03
2000	9.6	6.8	11.7	17.0	9.7	8.2	12.7	19.2	6.7	14.0	0.04
Projected seeds and waste rates as a percent of total consumption											
2025		5.9 ^b	9.9	10.1	9.7 ^a	5.9 ^b	12.7 ^a	19.2 ^a	5.5	14.0 ^a	0.04 ^a
2050		5.9 ^b	8.3	6.0	9.7 ^a	5.9 ^b	12.7 ^a	19.2 ^a	4.5	14.0 ^a	0.04 ^a
Total crop demand (Mmt)											
2000	201	82	67	18	20	14	49	7	75	47	26
2025	291	109	91	50	23	18	103	13	150	78	40
2050	377	117	102	121	16	21	133	24	189	123	52

Notes: ^a An increasing trend is seen in the growth of seeds and waste rates from 1980 to 2000. For them, we project the seeds and waste rates at the 2000 level.

^b The decreasing trends are significant in that the projected seeds and waste rates fall even below the seed rate in 2000. For them we assume the seed rates at the 2000 level.

Comparison with Other Food Demand Projections

We started our projections analyses with a view to assessing the impacts of recent consumption pattern changes on the NCIWRD commission's grain demand projections. A part of the deviation of various demand projections is attributable to the different assumptions of the total population projections. In order to make proper comparison, we standardized the projection to the same level of population as illustrated in Dyson and Hanchate 2000. Table 11 summarizes six demand projections. The latter four studies only estimate cereal demand. Therefore, the per capita demand of these studies is adjusted by adding the pulses demand of the present study (12 kg for food and 13 kg for total). The totals are adjusted to the population of 1,315 million by 2025 as projected by Dyson and Hanchate 2000, and of 1,581 million by 2050 as assumed by the NCIWRD commission.

Table 11. Grain demand projections of different studies.

Source of study	Demand/person (kg/year)				Total demand (Mmt)			
	2025		2050		2025		2050	
	Food	All	Food	All	Food	All	Food	All
Present study	166	210	152	238	218	276	241	377
NCIWRD	215	240	279	312	283	316	441	494
Dyson and Hanchate	159	182	-	-	209	239	-	-
Kumar	179	190	-	-	235	250	-	-
Bansil	180	202	-	-	237	266	-	-
Bhalla et al.	197	235	-	-	259	309	-	-

Sources: GOI 1999; Dyson and Hanchate 2000; Kumar 1998; Bansil 1999; Bhalla et al. 1999.

The present study and the NCIWRD projections differ in both food and feed consumption demand. The commission assumed a substantially high food grain consumption per person assuming a well-fed scenario for India. And for the well-fed scenario, the commission assumed a substantially high proportion of the nutritional intake from the food grains. But as discussed in the introductory section, this assumption converts to a substantially higher calorie intake per person, which is not realistic with the present trends of grain consumption in India or even in other developing countries in the world. Our study results differ a great deal from the commission's projections with respect to other non-grain crop and animal product consumptions. The non-grain food consumption will provide the majority of calorie intake in the present study (53 % in 2050, as against 35 % in 2000). The increased consumption of animal products, especially milk and poultry products in the present study, is reflected in a substantially high difference in the total and food grain demand. The feed grain demand comprises much of this difference.

The food demand projection of this study (166 kg/year in 2025) is higher than that of Dyson and Hanchate 2000, but lower than the latter three projections. Contrary to the current trends, Kumar, Bansil and Bhalla et al. studies projected increasing per capita cereal consumption. Dyson and Hanchate's projection is compatible with the current trends. But it is based by extrapolating the trends between 1987 and 1988 and 1993-1994 NSSO rounds. But the present study reflects the recent trends observed after the 1993-1994 NSSO survey.

The total grain demand projection of this paper is more closer to the Bansil 1999 and Bhalla et al. 1999 projection, primarily due to high feed demand for livestock. Is the nutritional supply of the projected consumption in the present study adequate for feeding well all the people in India by 2050? This study projects the average calorie supply at 3,000 kcal/ person/ day by 2050, and according to David Seckler (IWMI 2000), the average daily calorie intake of 2,700 kcal at the national level is adequate for providing the minimum nutritional intake of even the lowest income strata of any country (the minimum nutritional requirement of India is estimated to be about 2200 kcal/person/day). Indeed, the average calorie intake of the developed countries is 3200 kcal/person/day, and nutritional poverty is almost non-existent in these countries. However, barring any distributional difficulties, which will be much lower with better infrastructure in 50 years time, the projected food consumption will be adequate to provide the minimum nutritional supply for much of the Indian population.

Conclusion

This paper started assessing the recent food consumption pattern shifts in India and their implication for total crop demand. The recent trends clearly show changing patterns of consumption. While direct grain consumption is decreasing, non-grain product consumption in the daily diet is increasing in both rural and urban areas. This study projects that, with increasing income and urbanization, the non-grain crops and the animal products (dairy and poultry) would dominate the consumption basket by 2050. The contribution of grain products to the total calorie supply is projected to decrease from 65 % in 2000 to 55 and 48 % by 2025 and 2050, respectively. However, the total calorie supply is projected to increase to about 2,770 and 3,000 kcal/person/day by 2025 and 2050, respectively. This level of average calorie supply is sufficient for providing adequate nutritional security to the people even in the lowest income percentiles.

A major implication of the changing consumption pattern is the increasing feed grain demand. The total grain demand will increase from 201 Mmt in 2000 to 291 and 377 Mmt by 2025 and 2050, respectively. The feed demand is projected to increase many times, from a mere 8 Mmt at present to 38 and 117 Mmt by 2025 and 2050, respectively. The increasing feed grain demand is projected to consist of a major part of the total grain demand increase, 33 and 83 % respectively over the periods 2000-2025, and 2025-2050. The food demand projection in this study is significantly different from the NCIWRD projections. According to the commission, food grains provide the bulk of the nutritional demand in the future. This study holds a diametrically opposite view. The total food grain demand in the present study in 2050 is only 241 Mmt but the commission projects 441 Mmt. The total grain demand of the present study is 117 Mmt less than the commission projections. Thus, as mentioned in the introduction, the reservations expressed by many on the NCIWRD's projection increase in irrigated area (by 30 Mha), which is based on increased food grain demand, are justifiable. Thus, food grain demand cannot be a justification for large-scale water transfers such as aimed at by India's river linking project.

Another implication of the changing consumption patterns is the high level of consumption of non-grain crops. The demand for oil crops (including edible oil), vegetables and fruits will increase several times from the present level. In fact, India's predominance of food grains in the agriculture consumption and production patterns is changing. A major challenge for Indian agriculture in the next few decades in this century is how to meet the increasing demand for the feed grains. And even a greater challenge in the future is how India is going to meet the increasing demand for non-grain crops. The study shows the need for the diversification of future agricultural production, especially to high-value non-grain crops. The increasing demand for non-grain crop products will outpace the increasing demand for grains. Where and to what extent the crop diversification is possible depends on the access and availability of water resources and how they are consumed.

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