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The economics of food safety in India – a rapid assessment

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List of acronyms

CAR	Clinical Attack Rate
CFR	Case Fatality Ratio
CGE	Computable General Equilibrium Model
COI	Cost of illness approach
DALY	Disability Adjusted Life Year
FBD	Food born disease
FERG	Foodborne Disease Epidemiology Reference Group
FSSAI	Food Safety and Standards Authority of India
ILRI	International Livestock Research Institute
LMIC	Low and Middle Income Countries
MAGNET	Modular Applied GeNeral Equilibrium Tool
SAMs	Social Accounting Matrices
SEAR	South and East Asian Region
VSL	Value of a statistical life
WHO	World Health Organisation
WTP	Willingness to pay

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Executive Summary

Motivation of the study

Due to growing international trade, migration and travel, local foodborne disease outbreaks have become a potential threat to the entire globe (WHO, 2007). According to a recent WHO study (2015), there is a considerable foodborne disease burden affecting negatively people of all ages and particularly children under 5 years of age. Moreover, persons living in low-income sub regions of the world are disproportionally affected. This is particularly relevant in India, where despite growing recognition of the importance of food safety, India's public funding priorities don't reflect the substantive investments needed to bring its food safety system up to standard.

Understanding the costs of not having an adequate food safety system in India is thus crucial to lift its importance and visibility in the public debate. This study provides a rough estimate of such costs, using existing data and tools and discusses the resulting implications and actions needed for a more accurate estimate.

Methodology

This study is the result of a collaboration between experts on food safety from the International Livestock Institute (ILRI) and economists from Wageningen Economic Research. Using data from a recent WHO report on the global burden of foodborne disease, public available databases and literature, ILRI provided estimates of the current food-borne disease burden and related health costs, with possible importance of different foods in contributing to the burden. Using MAGNET, a global general equilibrium model developed at Wageningen Economic Research, the expected FBD burden in 2030 was estimated taking into account an increasing population, GDP growth and urbanization in India. Against this 2030 reference point economic implications of improving the currently inadequate food system were assessed using scenario analysis. The scenarios combine two channels through which a properly established food safety system benefits the Indian economy - increased labour supply (resulting from avoided food borne disease related morbidity and mortality) and savings in health care costs (resulting from avoided sickness which brings along savings on care and medication). The analyses were conducted in 2017 and a draft report was sent to food safety experts (see acknowledgements).

Current and Projected Food-Borne Disease Burden

About 100 million cases of food-borne diseases (FBD) are estimated for India in **2011**, but this is almost certainly an **underestimation** due to lack of accurate estimates and the available surveys. Since the FBD burden is related to consumption of specific types of food, a link was established between the number of cases and consumption of commodities susceptible for the food-borne diseases using four available studies from India and other regions. These provide lower and upper bounds of food disease burden estimates for India. An expert assessment of the applicability of these assessment methods for India was carried out in order to establish the reliability of this approach.

Given the expected significant economic growth between 2011 and 2030, population growth and urbanization, household incomes are expected to rise as a result of growing factor incomes (land rents and wages). This will be reflected in higher consumption of food, particularly fruits, vegetables and meat, which will result in a significant increase of FBD illnesses**. The number of FBD cases** is expected to rise **from 100 million to 150 – 177 million** in 2030 compared to 2011. This means that by 2030, **one out of 9** people on average fall sick, up from one out of 12 in 2011. However, rich rural and urban households will be disproportionally more affected than others, where **every third person could fall sick** from food diseases. It is important to note that the future FBD increase might be still higher given the likely underestimation of the current FBD burden.

Decomposition of various drivers show that the growing **FBD burden is attributed mostly to the GDP growth**, followed by population growth. The GDP effect provokes a significant increase of meat consumption by 2030 (albeit from a low base relative to meat consumption in the rest of the world), which is a highly susceptible food category for infectious food diseases. Next to that, **urbanization plays an important role for certain types of households.**

Due to rising domestic demand and food prices, the negligible share of exports will decline further. Given the limited role of primary agrarian foreign trade in the Indian economy, the **expected economic benefits of an improved food safety system will come from labour productivity and health improvements**. Their contributions were investigated in the scenario assessment, building on the qualitative expert assessment to obtain reliable FBD risk ratios pertinent to the local Indian conditions.

Scenario analysis of avoiding FBD burden

This study is, to our knowledge, the first assessment of economic impacts of food safety using an economy-wide (CGE) model. Despite limitations of the CGE approach, especially in the rather coarse representation of consumers, various interesting insights on the how the Indian economy can benefit from an increase in food safety system were derived. The CGE assessment accounts for both exogenous and endogenous macro-economic changes, providing a valuable complement to existing FBD cost estimates.

Food diseases burden on the richer households side. It is not guaranteed that households with higher income are less prone to fall sick by food-borne diseases. On the contrary, due to their preference for more luxurious types of food such as meat, fruit and vegetables, richer households are paradoxically more affected than lower income households. In view of the continuing process of urbanization and GDP growth, every third person in the rich urban household may be affected by FBD by 2030, which is notably more than the average one out of nine.

Therefore, avoiding FBD burden benefits richer households first. Establishing a food safety system that would reduce the FBD burden has thus direct positive impact on higher income urban households. Although an increase in labour supply results in decline of wages, land and capital prices go up which compensates the income gap of the rich households.

Other households benefit indirectly too as real incomes rise and food prices go down. Not only the richest households gain, but all other households will enjoy economic benefits of the food safety system. This is because a general decline in prices and rise in employment increases real incomes and makes food and services more affordable.

Positive structural changes in the economy in favour of tertiary sector. Because FBD-prone higher income households are better endowed with skilled labour, reduction in FBD related morbidity and mortality makes skilled-labour intensive sectors such as public and private services more competitive. In view of this, it can be concluded that the food safety policy is a policy that creates value added and positive structural change in the economy.

Governmental services such as education and health become more affordable for everyone. The two channels through which a reduced FBD burden affects the economy fuel each other – cheaper skilled labour (labour supply channel) and health care cost savings both make governmental services more accessible, not only health care but also other services such as education and sanitation. An increase in government services may further stimulate economic growth, for example through an increasing skilled labour force, but these long run investment benefits are not captured in the current model.

Positive GDP effects that are comparable to the estimates from the alternative methods. Total GDP effects are in range of 0.5%, which is equivalent to an annually recurring benefit of up to 28 billion USD (for the Tam method) falling in between two crude ILRI estimates of the FBD burden. The implied ratio between the GDP increase per one avoided FBD sickness is about 160 USD per case. Given the possible underestimation of the FBD burden, GDP gains could amount to 80 billion USD, if the illness ratio is one in three instead of one in nine.

Policy Implications

The results of the analysis show that investments in food safety can bring a positive impact on the Indian economy. Favourable structural change, support of employment of skilled labour and growth of services are all important positive effects of a food safety policy. Although the magnitudes of the effects are rather small, it is important to note that the seriousness of the FBD burden may be much higher than captured by the current data and therefore the potential benefits also much higher than those estimated in this study.

The important notion to highlight as well is that if no investments in food safety are made, the positive diet transformation from staple foods to more nutritious items such as meat, fruits and vegetables that is occurring elsewhere in the world could be jeopardized in India, as households would simply reject to consume these highly FBD-risky foods. Slowdown of the diet transformation can have then immense costs for the economy, in terms of poverty, undernutrition, obesity, supply chain underdevelopment and it may also affect the speed of urbanization.

Finally, it is important to note that the benefits of food safety are much broader than those quantified by economic models, for instance improved well-being and a reduced child mortality and morbidity of children, with repercussions on children school performance, birth and fertility rates.

1 Context

Important strides towards improving food safety in India have been made in the context of the Food Safety and Standards Act, 2006, and the establishment of the Food Safety and Standards Authority of India (FSSAI). Bringing India's food safety system up to acceptable standards, however, will require substantive investments. Considering that ensuring food safety has an important public good dimension, these investments to a large extent will need to come from the public budget. Although there is growing recognition of the importance of food safety, this is currently not reflected in India's public funding priorities.

This study provides a rough estimate of the cost of not having an adequate food safety system in India, aiming to lift its importance and visibility in the public debate. The approximate estimate based on existing data and tools is accompanied by a discussion on its probable accuracy and actions needed for a more accurate estimate.

Chapter 2 assesses the current food born disease (FBD) burden in India, attributing it to different food groups and providing an estimate of its costs using different calculation methods. With investments in food safety requiring time to materialize we employ a forward looking assessment of the economic benefits of improving food safety in India. Chapter 3 describes the methodology and data used in the economic assessment. Chapter 4 then provides and outlook to the FBD burden in 2030 if food safety remains at its current level, disentangling different drivers of FBD developments like population and income growth. Using this business-as-usual situation in 2030 as a reference point we explore the economic impacts of two key channels through which investments in food safety will materialize in Chapter 5: increased labour productivity and reduced health costs. Chapter 6 concludes.

2 Evidence on the current FBD burden in India

To be able to estimate the benefits of improving India's food safety we first need to assess the current impact of foodborne diseases. Compiling the (limited) available evidence we first establish the FBD burden. To be able to establish future developments in FBD burden we associate the FBD burden to different types of food. These two parts are key inputs for the macro-economic assessment of benefits of improving food safety in Chapter 3 through 5, which accounts for expected population and income growth. Costs of FBD are not regularly assessed in a macro-economic framework. The last part of this chapter estimates the current costs of the FBD burden using more common methods, which can be used to place the macro-economic assessments in perspective.

2.1 Assessment of the foodborne disease health burden

2.1.1 Measuring FBD

Foodborne diseases (FBD) are illnesses caused by contaminated, or naturally harmful, food or beverages.

The health impacts of FBD can be measured in different ways, including annual cases of sickness and death, and severity. There is also a standard metric for measuring disease burden: the Disability Adjusted Life Year (DALY). One DALY is the equivalent of one lost year of healthy life, combining the burden due to sickness and death. Measuring health impact in DALYs allows comparisons between dissimilar diseases and aids in prioritization.

There is little empirical information on the burden of FBD in Low and Middle Income Countries (LMIC) (Grace et al., 2015). The main sources of information are: official reports; epidemiological surveys; risk assessments; media reports; and, health burden assessments.

2.1.2 Best estimates of the burden of FBD for India

Our review found that the best estimates of FBD in India were those provided by the recent World Health Organisation (WHO) Foodborne Disease Epidemiology Reference Group (FERG) (Havelaar et al., 2015). Results are not given for specific countries, but rather for groups of countries with similar health status. India is part of group D along with 7 other countries (including, for example, Maldives and Bangladesh). India comprises 83% of the population of group D and because countries are grouped by similar health status we can assume that the per capita FBD illness for group D overall corresponds well to the per capita FBD burden of India.

Using FERG data, which refers to the year 2010, the burdens shown in Table 1 are found. The FERG distinguishes four categories of FBD: diarrhoeal (e.g. shigellosis), invasive infectious (e.g. hepatitis), parasitic (e.g. pig tapeworm) and chemical (e.g. aflatoxins). Diarrhoeal diseases are most common but least severe, leading to differences in impact depending on whether cases, deaths, or disease burden are considered. Conversions to total numbers are based on the Census of India conducted also in 2010 (population 1.2 billion). This burden study estimates there are nearly 100 million cases of FBD in India per year (Table 1). This corresponds to around one in 12 people falling ill of FBD. There are around 120,000 deaths each year and FBD imposes a burden of over 8 million Disability Adjusted Life Years (DALYs).

Although the FERG is the most accurate estimate of FBD, it likely underestimates the true burden because not all causes of FBD are included, not all consequences are considered and the methods for estimating are conservative. The FERG co-authors summarise other data limitations including large uncertainty intervals. Some countries have conducted national studies on the burden of FBD: for example, in Greece one in 3 people are affected each year (Gkogka et al., 2011) and in the USA 1 in 6 people (CDC, 2016): it is therefore likely that more a year are affected in India than the 1 in 12 people estimated by the FERG.

Table 1: Annual burden of foodborne disease in India (2010)

	All ages	*Five and above*	*Under five*
Cases foodborne disease	97,491,276	57,922,042	39,569,234
Cases foodborne diarrhoeal diseases	78,519,675	43,636,435	34,883,240
Deaths foodborne disease	117,174	87,844	29,330
Deaths foodborne diarrhoeal disease	64,227	43,922	20,305
DALYs foodborne disease	8,398,845	5,391,417	3,007,429
DALYs foodborne diarrhoeal disease	4,416,152	2,525,511	1,890,642

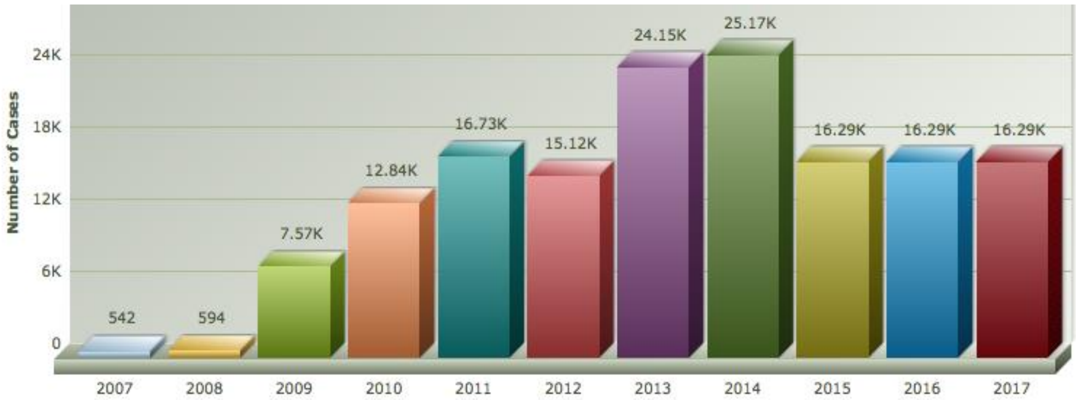
Sources: FERG report and GOI census

2.1.3 Other estimates of foodborne disease in India

Official reports appear to under-estimate the burden of FBD by orders of magnitude. Literature reviews find only a few outbreaks reported a year. There is hence a major disconnect between official reports and the burden of disease estimates.

The Foodborne Disease Surveillance Portal of the Indian Council of Medical Research maintains a database of FBD reported in the media (http://218.248.6.43:8080). Results are shown in Figure 1.

Figure 1: Food poisoning cases per year obtained from news, print and mass media



Source: Foodborne Disease Surveillance Portal of the Indian Council of Medical Research

Community surveys are good ways of finding out the frequency of gastro-intestinal disease in a given context. Reviews suggest children have 1-2 episodes of diarrhoea a year (Lakshminarayanan & Jayalakshmy, 2015). However, the proportion due to food is not assessed. Some surveys also ask people if they believe the illness was foodborne. This is not very accurate, as people cannot easily tell the source of their illness. There are relatively few reports from India. However, a recent large study reported 3.4 episodes of FBD per year per person and outbreaks of FBD in 3% of the villages surveyed during the previous year (Polasa et al., 2006).

Quantitative risk assessments predict the level of FBD based on the level of hazards in food consumed, the quantity consumed and the susceptibility of the population. Only few are reported from India, but these also suggest high levels of illness (QMRAwiki, 2017). A comparison between different sources is shown in Table 2.

Table 2: Comparing different estimates of numbers of foodborne disease per year in India

	Implied cases of FBD per year in India	*Bias in information*	*Credibility of information*
Community surveys	Around 3 billion	Over-estimate?	Moderate
Comparisons with other countries	Around 400 million	Either direction	Moderate
World Health Organisation	Around 100 million	Under-estimate	High
Media reports	Around 20,000	Under-estimate	Low
Official reports	Around 100	Under-estimate	Low

Source: Authors' compilation

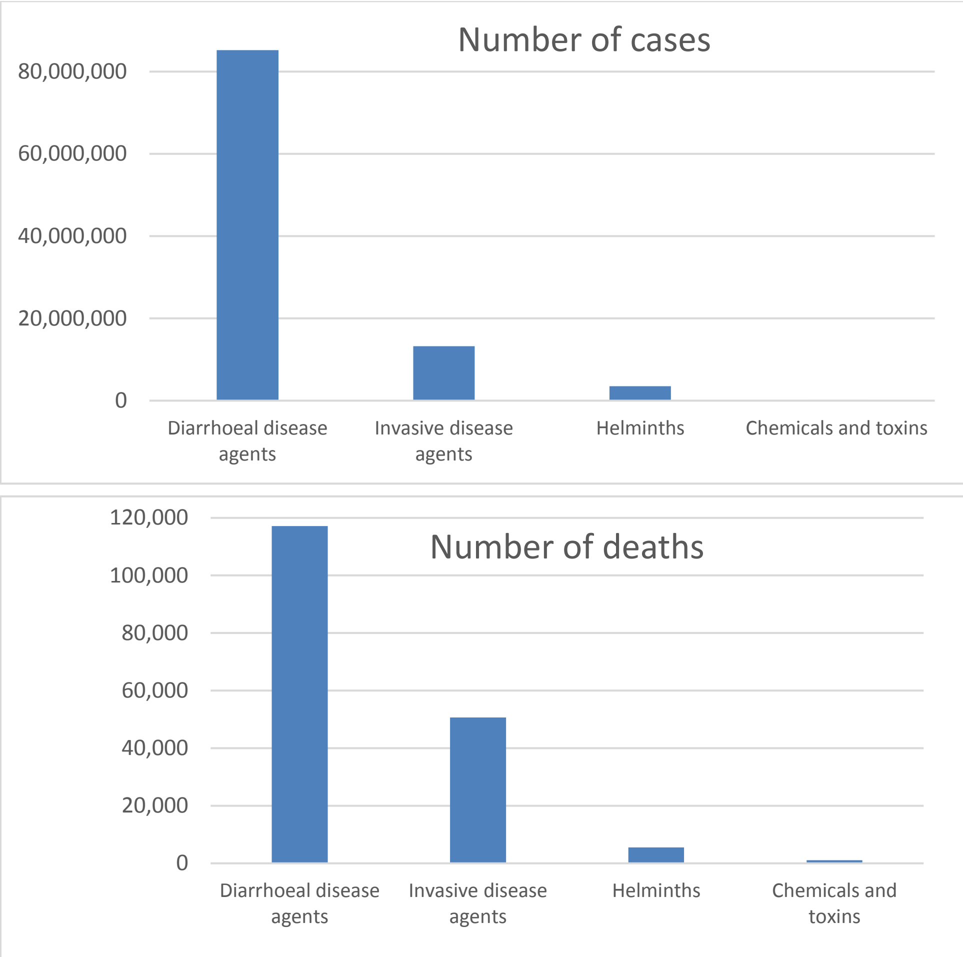
2.2 Probable importance of different hazards in contributing to the FBD burden

A food safety hazard is anything in food that can harm consumers' health. There are three major types of hazards: biological, chemical and physical.

- *Biological hazards* are living organisms (including viruses, bacteria, protozoa, moulds and parasites), which have the ability to infect people or produce toxins injurious to health.
- *Chemical hazards* can be artificial chemicals produced by industry or natural chemicals (for example, those produced by heating food or toxic metals), which are injurious to health.
- *Physical hazards* include stones and fragments of metal or glass as well as sub-microscopic nanomaterials and radionuclides.

Disease burden studies provide a systematic, structured method for attributing disease burden to different hazards. Using the FERG study is probably the most robust way of understanding the relative burden due to different hazards in India (Figure 2). As mentioned, the FERG considers FBD under four different categories. Although diarrhoea is the most common result of consuming hazards in food, non-diarrhoeal FBD tend to have more severe effects (for example, epilepsy or septicaemia). Around 80% of cases of FBD are due to diarrhoeal agents but these are responsible for only 55% of the deaths and 53% of the burden.

Figure 2: Comparing different estimates of numbers of foodborne disease per year in India



Source: Authors' elaboration

2.3 Foods implicated in FBD in India

Understanding the foods responsible for FBD is not straightforward. Epidemiological investigations can reveal statistical associations between foods consumed and illness, but these require good data on consumption, which is often lacking. Molecular analysis allows the relation between bacteria found in food, animal reservoirs and those found in sick people to be analysed. Again, there is not much data from India. In all, we found only one epidemiological study from Hyderabad (Sudershan et al., 2014).

However, some other countries have conducted attribution studies of varying quality to see which foods are responsible and the results are shown in Figure 3. These are from countries where diets, food environments and food preparation and consumption are very different from India, so caution must be exercised in extrapolating the results. Yet, it can be seen that the one small study from India was broadly comparable with other studies, indicating that animal source food (i.e. fresh meat, milk, eggs, fish) and produce[1] are important causes of foodborne disease (although we should note that large groups of the population do not consume some or all of these products in India). Meat consumption is a strong predictor of foodborne disease mortality. In a cross- country study, for every additional metric ton of meat consumed

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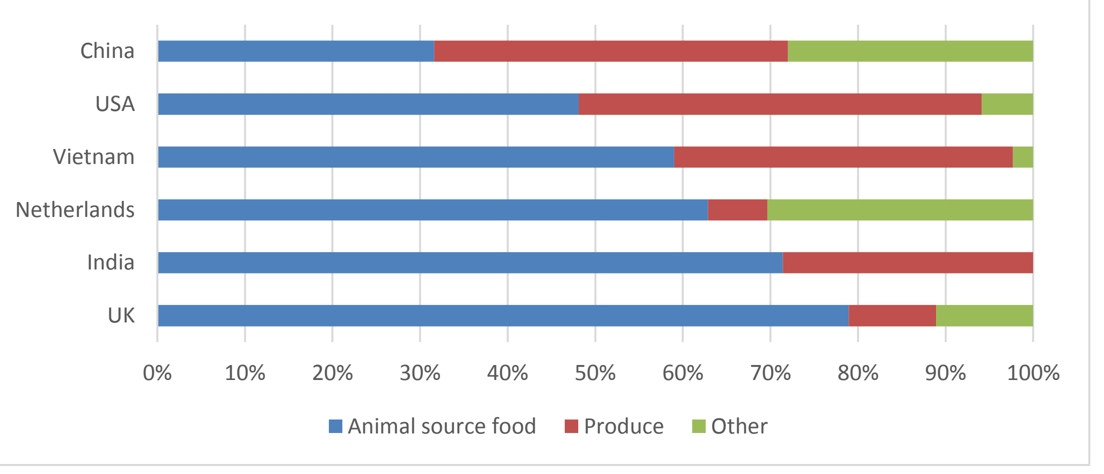
[1] Produce here means raw vegetables and fruit: in general, vegetables are more risky than fruits especially those grown in fields, fertilised with animal or human waste, and eaten raw or minimally cooked (Hussain and Gooneratne, 2017)

per 100 people, foodborne disease mortality increased by 6% (Hanson et al., 2012). In developing countries, less fresh food (animal source foods and produce) is eaten, but the fresh food (animal source foods and produce) eaten is more contaminated.

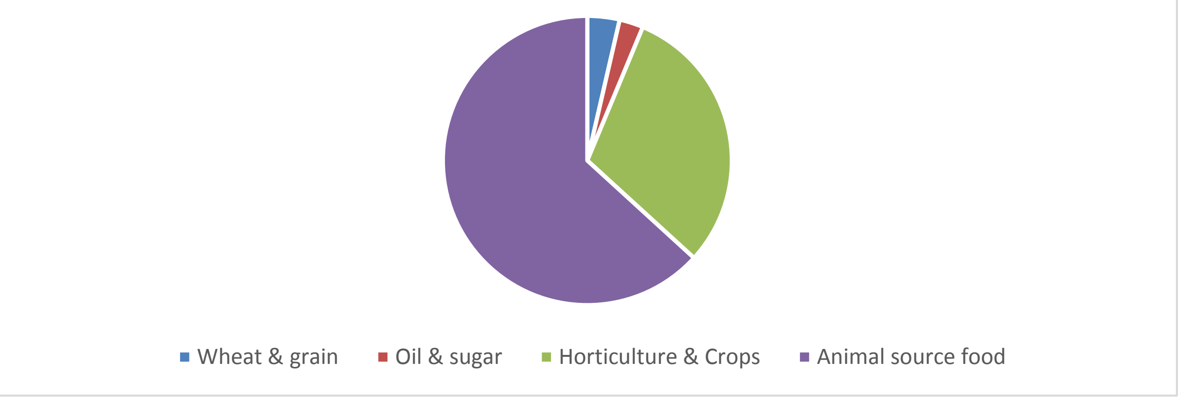
Figure 3: Studies attributing FBD to different foods



Source: Authors' elaboration (sources from Grace, 2015)

Given the lack of epidemiological information, we also used a biological approach to estimating the burden of FBD due to different foods. We did this by consulting the CDC "Bad Bug Book" (Food and Drug Administration, 2012) to identify which pathogens were associated with different food categories. If there was an association with foods, then the burden was allocated to these foods. If there was no association with a food, the burden due to a hazard was equally allocated to all foods. Weighting was applied according to whether foods had major or minor associations. This suggested the following (Figure 4).

Figure 4: Biological approach to attributing the FBD in India to different foods



Source: Authors' elaboration

These allocation approaches do not take into account that some hazards are consistently associated with different burdens. Apart from one small study, they are not based on data collected in India. Nonetheless there is some broad agreement between studies and approaches: generally, animal source foods are the most important sources of FBD followed by produce.

2.4 FBD related costs

Foodborne diseases are associated with a wide range of economic costs. These can be divided into: a) the harm caused by the disease (e.g. lost productivity from illness); b) the cost of response (e.g. treatment, food recalls); and, c) cost of prevention (e.g. food safety governance, risk reducing practices) (Shaw & Grace, 2015). Alternatively, costs may be allocated to different actors (consumer, health care, agro-food industry, government (McLinden et al., 2014)). Zoonotic diseases often exert additional burdens on the livestock sector and it is important that estimates of costs cover multiple sectors.

Unfortunately, economic information on FBD from developing countries is even more lacking than health information. Most work has been conducted on trade issues and costs of compliance, and a relatively substantial literature exists (Unnevehr & Ronchi, 2014; Humphrey, 2017); however, this covers only a small proportion of food produced and has little relevance to FBD in LMICs. Some studies assess economic burden of specific FBD hazards, either nationally or for a region. Lack of information on economic costs is often cited as a major reason for lack of prioritisation by decision makers.

In this section, we briefly describe some approaches to assessing the economic cost of foodborne disease and compare the estimates.

2.4.1 Human capital approach – value of a statistical life

Loss of life may account for the biggest share of health valuation estimates (Narain and Sall, 2016). In economic terms the value of a statistical life (VSL) is the amount of money a person (or society) is willing to spend to save a life. The only way to measure the VSL is through indirect methods (e.g., surveys or observed human behaviour in risky environments). Various methods have been used, such as discounting forgone income, and using wage differences between occupations with different risks. There are several studies from India (with a wide range of values, see Table 3). Studies generally provide average values for the overall population although there is some evidence that values may be different for adults and children. Using these VSL estimates and the FERG estimates for deaths in 2010, the cost is $42 billion USD (Table 4).

Table 3: Studies estimating the value of a statistical life in India

Author and year	***Value of Statistical Life***	***Value 2010 USD***
Nathalie et al. (1999)	153,000- 358,000 USD	375,740
Madheswaran (2004)	15 million INR	430,275
Shanmugam & Madheswaran (2004)	3.74 million INR	276,768
Average		360,928

Source: Author's compilation

Table 4: Cost of foodborne disease in India: value of a statistical life approach

Deaths from foodborne disease	*Average value of a statistical life*	*Cost of foodborne disease*
117,174	360,928	42,291,239,670

Source: Authors' elaboration

2.4.2 Human capital approach – lost GDP

Loss of life can also be estimated as foregone output. It is an income-based approach and equates the financial cost of premature mortality with the present value of forgone lifetime earnings. The value of DALYs lost due to FBD can be calculated by multiplying the estimated DALYs loss due to FBD in the FERG data by the GDP, income or purchasing power parity adjusted income per capita for the same year, using human capital approach as in the paper on Economic Burden for Injuries (Dalal et al., 2013). Using per capita data from the World Bank for 2010 (World Bank, 2017) and FERG estimates for deaths in 2010 the cost is $12 to $56 billion (Table 5). Other economists use the friction method, which results in much lower costs.

Table 5: Cost of foodborne disease in India: human capital approach

DALYs from foodborne disease	*USD 2010*	*Cost of foodborne disease*
8,609,179	1,387 GDP	11,948,507,193
	1,680 per capita income	14,463,420,720
	6,490 per capita income ppp adjusted	55,873.571,710

Source: Authors' elaboration

2.4.3 Cost of illness approach

The cost of illness (COI) approach seeks to account for the direct and indirect costs of death and illness. Direct financial costs include transport costs to get treatment, medical expenses paid by the patient, wages lost, and costs of public health provision. Indirect costs include productivity losses from missed business due to sick employees, the monetized value forgone household chores and others. There is some inconsistency in whether costs are considered direct or indirect in the literature.

We found COI studies for cholera in India (Poulos et al., 2012). In addition, we found several studies on costs associated with diarrhoea from India. We extrapolated these estimates to national level, although several studies referred to specific locations and so may not be generalizable. We considered direct costs to patients and their families, indirect costs to patients and their families and government costs. For the latter we relied on the Report of the National Commission of Macroeconomics and Health (MOHFW, 2005).

The disease for which there were cost data from India (diarrhoea and salmonellosis) accounted for 72% of the health burden in DALYs. We also extrapolated the total cost, assuming that the diseases without information had similar cost per DALY to those with information. This may not be plausible. In other countries, pathogens which cause more severe illness are responsible for a disproportionately high economic cost, even if they are less common. In the US, for example, toxoplasmosis and listeriosis are among the top 3 most costly illnesses. However, we did not have information on costs for India and it is possible that costs are relatively less in India because opportunities for more expensive care are fewer. The estimated cost was around $2 billion (Table 6).

Table 6: Cost of illness associated with some foodborne or food associated diseases in India

	Children			Adults			
	Cost per case	*Cases 100,000)*	*Cost (million)*	*Cost per case*	*Cases 100,000)*	*Cost (million)*	**Total**
Diarrhoea	13	349	463	15	436	655	**1,117**
Salmonella typhi	17	6	10	72	24	172	**182**
S. paratyphi	17	1	2	72	5	40	**42**
Cost of diseases with COI information representing 72.3% of the health burden							**1,341**
Imputed cost of all foodborne disease							**1,837**

Source: Authors' elaboration

2.4.4 Willingness to pay approach

Willingness to pay (WTP) for reduced FBD can be decomposed into four components: the costs of treating the illness; forgone income from lost work time; costs of averting illness; and the disutility of illness (Antle, 1999). Theoretically, WTP depends on income, prices, and perceived risk in terms of severity and likelihood. A number of studies have estimated WTP for food safety, often using contingent valuation, which asks individuals what they would be willing to pay, contingent on market availability of the product or service. Revealed preference studies examine consumers' actions in actual marketplace settings and are more valid but more difficult to perform. A number of studies have been conducted in LMIC. Studies using stated preferences typically find that in hypothetical settings, LMIC consumers also are willing to pay substantial market premiums for safer food (Jabber et al., 2010). One study in India, based on revealed preferences, found supermarket consumers, provided with information about safety, were willing to pay more for grapes with credible food safety certification (Birol et al., 2015).

We can compare these results with economic studies from other countries (Table 7). An assessment in the Netherlands found that the costs attributable to 14 foodborne pathogens in 2011 was $217 million (Mangen et al., 2013). Fish, fruit and vegetables, beverages, grains and other foods account for 8%, 6%, 2% 5% and 14% of the costs attributed to food, respectively. Direct costs included doctor's fees, hospitalizations and medicines, and accounted for less than 25% of all costs. Costs paid by patients, such as travel costs to and from the doctor, are called direct non-healthcare costs. These are low. Productivity losses due to work absence of patients and special education as a consequence of neurological disease are called indirect non-healthcare costs. These are substantial and amounted up to 75% of the total costs.

In the USA, cost estimates of 15 FBD were developed by the USDA using COI methods (2017). These 15 pathogens cause over 95 percent of the 9.4 million cases of foodborne illness in the United States for which a pathogen cause can be identified. ERS estimates that these 15 pathogens impose $15.5 billion per year in medical costs, wages lost from time away from work, and societal willingness to prevent premature deaths.

If we use the estimates from these studies and apply them directly to India, they cover 68% and 50% of the diseases in the group "SEAR D" in the FERG study respectively. This amounts to $139 billion and $167 billion and if extrapolated to all the FERG diseases, to $203 billion and $334 billion respectively. Of course, all direct and indirect costs are considerably lower in India; however, this is an indicator of the levels to which costs might rise if economic development in India converged on that of OECD countries, but levels of FBD remained much higher.

Table 7: Valuing current levels of illness in India at current costs of illness in the Netherlands and USA

	Cases in India	*Cost in US per case*	*Cost in NL per case*	*Total cost based on USA estimates*	*Total cost based on NL estimates*
Norovirus	8,453,220	413	197	3,491,179,860	1,665,284,340
Campylobacter	11,709,018	2,283	980	26,731,688,094	11,474,837,640
STEC	213,514	4,298	6	917,683,172	1,281,084
Other E coli	16,982,859	243	-	4,126,834,737	0
NT Salmonella	8,230,400	3,568	829	29,366,067,200	6,823,001,600
Shigella	11,397,108	1,051	-	11,978,360,508	0
Cryptopsoridium	741,232	899	374	666,367,568	277,220,768
Giardia	1,453,352	-	233	0	338,631,016
Hepatitis A	7,163,276	489	1,847	3,502,841,751	13,230,569,967
Toxoplasmosis	1,472,721	38,114	90,032	56,131,305,988	132,592,059,103
Listeria	1,211	1,781,548	138,482	2,157,454,628	167,701,702
Total	**67,817,911**			**139,069,783,505**	**166,570,587,220**

NT Salmonella= Non typhoidal Salmonella

Source: Authors' elaboration

2.5 Key findings on the current FBD burden in India

Based on the most accurate available data from the Foodborne Disease Epidemiology Group of the WHO, the FBD burden in India was estimated adopting the disease burden for the South East Asia Group B. Combining four different types of food burden diseases, namely diarrhoeal, infectious, parasitic and chemical, it is estimated that the current FBD burden in India represents about **100 million cases per year**. This corresponds to **one in 12 people falling ill**, which might be well **underestimated** as not all causes and symptoms are recorded and the methods are rather conservative (up to 3 billion cases could be the true FBD burden if community surveys would be used as a reference, however, their coverage is limited).

Although there is a clear association between foods consumed and illness, the lack of epidemiological and consumption data makes it difficult to establish a precise relation. The limited studies that are available identify **animal source of food, raw vegetables and fruit are important causes of foodborne disease.**

Finally, a first assessment of economic cost of foodborne diseases was made using several alternative methods. Applying the human capital approach, the economic costs are in range **of USD 12 billion to 55 billion USD** when valuing loss of life or forgone output. Applying the cost of illness approach, imputed costs of all foodborne diseases range about 2 billion USD, but may be as much as 300 billion USD when evaluated at US costs of treatment. These crude estimates provide a reference for the results of the macro-economic model MAGNET, which is introduced in the following chapter.

3 Methodological approach of the macro-economic assessment

The FBD burden is not a static concept but changes over time depending on the size of the population, risks of different food types and consumption patterns. Food safety improvements will not take place instantaneously, and an assessment of the economic benefits of the required investments thus need to account for changes in drivers of the FBD burden. To this end we use a macro-economic model, MAGNET, to assess the FBD burden and potential benefits of improving food safety by 2030 when an improved food safety system could be fully operational.

In this chapter we shortly introduce the MAGNET model and databases and discuss the key drivers of the scenarios employed in this study. A critical part of the analysis it to translate the ILRI FBD estimates into MAGNET-compatible scenarios, as outlined in Figure 5. These steps are discussed in detail in the remainder of this chapter.

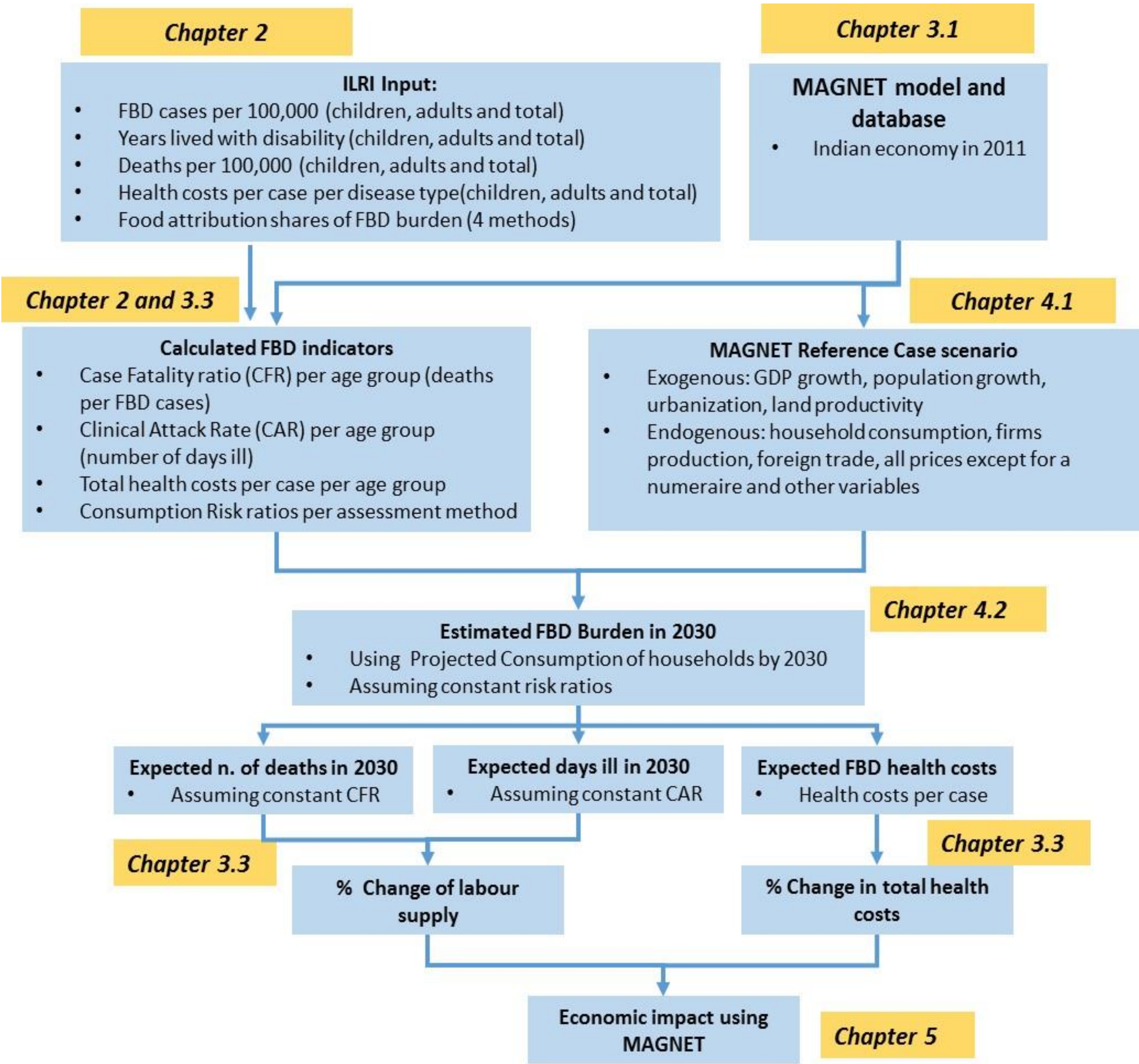


Figure 5: Schematic overview of converting the ILRI estimates of FBD burden into MAGNET shocks

3.1 MAGNET model and databases

MAGNET (Modular Applied GeNeral Equilibrium Tool) is a multi-sector, multi-region Computable General Equilibrium model of the world economy (Woltjer et al. 2014) which has been widely used to simulate the impacts of agricultural, trade, land and biofuel policies on the global economy, as well as for long-term projections. MAGNET is based on the GTAP model, which accounts for the behaviour of households, firms, and the government in the global economy and how they interact in markets, tracing all economic transactions captured by national statistics[2] (Hertel 1997).

The model includes the food supply chain from farm, as represented by agricultural sectors - via food processing industries and food service sectors - to fork taking into account bilateral trade flows for major countries and regions in the world. MAGNET has been extended from the GTAP model so as to make it suitable for in-depth analyses in the area of agriculture, characterised by competing demands from food, feed and biofuels, and food and nutrition security by distinguishing different household types for selected regions and tracing flows of macro-nutrients (calories, fat, proteins, carbohydrates) from primary production to final consumption. The extensions have been added in separate modules to the GTAP core, which can be switched on or off depending on the policy question at hand, making MAGNET particularly flexible for use in applied policy analyses. The model has been developed at Wageningen Economic Research and is applied and further extended at the Joint Research Center Institute for Prospective Technological Studies (JRC/IPTS) and Thünen Institute (TI).

The MAGNET[3] database includes additional household detail for India distinguishing ten household types based on five income levels combined with a rural-urban distinction. Including the household module allows tracking of the implications of urbanization trends and possible differences in rural and urban diets which may affect the FBD risk.

Apart from the module activation the sector and regional aggregation is key[4]. Given the focus of this study a model version with maximum possible detail in terms of food products is chosen within the limits posed by the MAGNET database. As the starting point for quantifying the global economy MAGNET uses the GTAP V9.2 interim release database with 2011 as reference year (Narayanan, Aguiar, and McDougall 2015). The GTAP database contains detailed bilateral trade, transport and protection data (import tariffs, export subsidies and subsidies to agricultural outputs, inputs and factor payments) characterizing economic linkages in 57 sectors among 141 countries or regions, together with detailed country input-output databases accounting for domestic inter-sectoral linkages.

The GTAP database is combined with other databases providing the necessary detail for the modular extensions, like FAOSTAT to model land supply and trace agricultural production in quantity terms and national Social Accounting Matrices (SAMs) to add household level detail.

Annex 1 describes the sectors (products) and regions (countries or groups of countries) distinguished in the MAGNET model used in this study, including a more detail breakdown of the commodities covered by each sector. We can distinguish 11 primary food commodities and 10 processed food types. The FBD column indicates if these commodities are fall in categories likely to be subject to FBD: stapes, dairy, meat & fish, vegetables & fruit.

To be able to assess impacts on health costs government services are separated from other service sectors. Health services are, however, lumped together with a wide range of other government services limiting the ability to trace the impact of health services alone.

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[2] Being derived from national statistics, the GTAP databases excludes economic activities not registered by statistical offices. Activities in the informal economy or farm production directly consumed by farm households may thus not be accounted for.

[3] This study is done with the MAGNET - Release_May2016, revision 7002.

[4] For computational reasons the model is run using an aggregated version of the MAGNET database.

Changes in labour productivity are likely to affect sectors differently depending on the labour intensity of production. Therefore manufacturing sectors are aggregated into two types (low and high tech) based on relative labour shares in total value-added.

The second dimension of the model is the regional aggregation, which determines the extent to which the model is able to trace specific bilateral trade flows. Based on the current export shares for primary and processed food we selected key trade partners of India while keeping a coarse resolution for the rest of the world.

3.2 Scenario set-up

Through comparative static scenarios different macro-economic implications of improving food safety in India are explored. The reference point for these comparisons is the (global) economy in 2030 under a business-as-usual scenario. The alternative scenarios thus explore how different the Indian economy will look in 2030 if effective food safety measures would be in place. Table 8 presents an overview of the scenarios, their purpose and data sources parameterization.

3.2.1 Defining the reference point

The impact of food safety measures depend on autonomous developments in the economy, like increases in income per capita and urbanization rates which both affect the demand pattern of households. The core GTAP database has 2011 as a reference year, while the India SAM used to calibrate the household module is based on 2006 data[5]. Given the importance of the autonomous drivers and taking into account that food safety measures will not be effective instantaneously we calibrate the model to 2030 projections of key drivers for which data are readily available - population and GDP growth for all model regions, the rate of urbanization in India (affects the relative size of rural and urban household types). Assumptions on the productivity growth of land and natural resources (fisheries) are also implemented.

Box 1: Socioeconomic status rather than urbanization shifts the diets

When looking specifically at India, diet transformation occurs both in rural and urban areas. Varadharajan, Thomas and Kurpad, (2013) analysed poverty and state of nutrition in India between 1987-88 and 2009-10 and found that spending on cereals and millets has decreased around threefold in both rural and urban settings **moving from low to high socioeconomic groups.**

Similarly, Tripathy et al. (2016) reported **minimal urban-rural differences in dietary habits** and levels of physical activity in India (mean number of servings of fruits and/or vegetables per day was found to be 2.3 and 2.2 in urban and rural areas respectively). The authors consequently argue that **urbanisation in India is progressing along a path very different from the conventional migration to big cities.** They explain that as villages start urbanising, their consumption habits change as well. **The rural consumption basket of 2010 was surprisingly similar to the urban basket of 1994**. The urbanisation of rural villages might be responsible for the reduction in the urban rural difference in dietary patterns, physical activity and obesity that existed before.

Similarly, Cockx and De Weerdt (2016) found that living in an urban environment does not contribute positively to the intake of protein-rich foods, nor to diet diversity. Their results however also indicate that the **growth of unhealthy food consumption with urbanization is largely linked to rising incomes.**

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[5] The India household module is calibrated on Ganesh-Kumar, A. and M. Panda, 2009. A 2006-2007 Social Accounting Matrix for India. Unpublished mimeo. Indira Gandhi Institute of Development Research, Mumbai.

Concerning shifts in diets, the reference case captures changes provoked by income growth (with increasing income, for example, demand for meat grows quicker than for staple food). Although it could be argued that urbanization may also play a role in diets transformation, the existing empirical evidence does not support this assumption (Box 1).

With non-existing food safety system, the increasing emergence of food-borne diseases might lead to the lack of trust consumers towards domestic production and a shift to imported goods. However, when looking at the existing consumer preferences in India, the current data do not indicate that Indian consumers are preferring imports because of food safety reasons. Even if such a preference would exist the current trade policy of India prevents it from materializing. Moreover, the empirical evidence on food scandals shows that the impact of these events are rather short-term. Low current import share and (implicit) trade barriers therefore make the flexibility of moving preferences towards imported food conceptually difficult to model in MAGNET, taking into account the specific features of this model (Box 2). For these reasons, the reference case scenario does not include any explicit change of preferences from domestic to imported goods. This does not mean that preferences for imported vs domestic food are constant, but these preferences are driven purely by price differential and not by quality.

Box 2: No easy shift away towards the imported goods in MAGNET

- *A "small-share problem"*

With initially small share of imports in the base year, MAGNET projections towards 2030 will produce solutions that are close to the initial situation.

- *Armington assumption*

Because of highly aggregated food categories in MAGNET, there is no perfect substitution between domestic and foreign goods. Therefore it is not possible to source consumption only from imports or only from domestic production. Even with a significant increase of substitution elasticity between imports and domestic goods for certain types of households (making products almost perfect substitutes), imports share change in range of percentage points, if not accompanied by a parallel changes in trade policy.

- *Explicit and implicit trade barriers for importing agricultural products*

Various reports indicate that the official trade barriers for India not properly capturing actual protection in place. This may change in the future with rising incomes, but a complete reversal away from domestic production seems unlikely.

- *Food scandals are short-term but MAGNET is medium-long term model*

A review of the available evidence on the trade impacts of food scandals finds very limited impacts which quickly disappear (Arnade et al. 2009 , Lusk et al. 2002, Piggott et al., 2004). Given these small and non-persisting impacts, it is difficult to capture them in MAGNET being a CGE model proving an equilibrium situation after the markets settle.

3.2.2 Increasing labour supply

Drawing from the empirical evidence on food borne diseases in chapter 2.4, there is a substantial impact of food-borne diseases on labour force resulting from work absence of patients. Improving health status of the population through a well-established food safety system has thus direct effects on the labour force.

In a CGE framework, this has been modelled for instance in study that focus on the impact of saturated fat consumption on cardiovascular diseases (Lock et al., 2010). The authors reduce labour supply due to expected loss-of-years-of-life and they reduce labour productivity due to reduction of life disability. In Bosello (2006), labour productivity effects are modelled as a response to climate change related diseases such as malaria, dengue or diarrhoea. The authors assume that the annual loss of labour productivity is assumed to be equal to the number of additional malaria deaths plus the additional years of life diseased by malaria, divided by the total population.

The approach taken in this study follows the above mentioned examples but it also takes into account a variable food safety risk exposure to certain commodity groups. The impact of improved food safety burden will be modelled by increasing labour supply. It is expected that economic growth and urbanization will result in changes in consumption patterns which vary by household group. Date permitting improvements in food safety and reduction of the avoidance of additional deaths will be consequently translated into the increase of supply by household type.

3.2.3 Reducing health care costs

CGE models are important tools to model health care costs as they enable to trace the key economic relationships in health care cost growth: demand for health care, supply of health care, and technological growth (US National Research Council, 2010). Modelling health-care expenditures in CGE model has been done for instance in Rutten and Reed (2009). In Bosello (2006), the implications of climate change induced diseases on higher health care costs have been modelled by lowering the health services productivity, with resulting increased public consumption on account of expenditures on other industries.

There are two alternative ways the reduced health care costs resulting from improved food safety can be brought into the MAGNET model:

- *Explicitly reducing governmental and/or private household expenditures* for public services: Health care sector in the GTAP database is part of public services sector. Knowing costs savings of improved food safety can be directly implemented into MAGNET by reducing expenditures on public services paid either by household or government. In order to maintain the budget constraint, the reduced expenditures can be spent on other alternative commodities.
- *Increasing total factor productivity of public services sector*: this means that the same health services quantity is produced with lower costs, or that there are more health services with the same expenditures. Either way, health care component of public services will be cheaper and the agents will have more income spent on other goods.

The second option, adjusting the factor productivity, requires less data on the actual health expenditures by households and governments. The implicit assumption in this scenario is that expenditures on government services, also encompassing education, social security etc. (see Annex 1), remain stable while the amount of services delivered for this expenditure increases. Given the scope of the current project it is proposed to capture reduced health costs through an increased productivity of the government services sector. This avoids collection and processing of data on health expenditures. The implicit assumption that the savings in FBD health costs are used to finance other health or public services also seems reasonable.

Translating the ILRI findings on the current FBD burden in India into MAGNET-compatible scenario shocks is not straightforward. The approach taken, with the underlying assumptions is discussed in detail in the remainder of this chapter.

Table 8: Scenario overview with data sources

Code	*Name*	*Key drivers*	*Data needs*	*Data source*
REF	Reference case	- Population growth	- Global population projections 2011-2030	- SSP database (v9)
		- GDP growth	- Global GDP projections 2011-2030	- SSP database (v9)
		- Urbanization in India	- Rural vs urban population India 2011-2030	- World Bank Population Estimates and Projections
		- Income inequality	- Inequality 2011 (2030 inequality follows from endogenous income developments)	- World Income Inequality Database
LAB	Labour impact	- Mortality related Labour supply	- Avoided deaths through increased food safety	- ILRI estimates of FBD burden per 100,000 inhabitants and by food type and MAGNET household data
		- Morbidity related Labour supply	- Avoided sickness (number of days ill)	- ILRI estimates of FBD burden per 100,000 inhabitants and by food type and MAGNET household data
HLT	Health costs	- Productivity of government service sector India	- Share of health expenditures in government services	- WHO Global Health Expenditure database
			- Reduction in health costs due to food safety investment	- ILRI estimates
TOT	Total impact	- All scenario-specific drivers defined above	- All data defined above	- From sources defined above

3.3 Translation of FBD data into MAGNET shocks

To be able to explore the potential economic benefit of improving India's food safety system we have to translate FBD estimates from ILRI into MAGNET compatible shocks. This conversion of the FDB burden into labour supply and health care costs is outlined in Figure 5. First, we estimate the number of FBD illnesses attributed to specific foods using risk ratios from the four alternative assessment methods. Consequently, we calculate corresponding labour and health care shocks that simulate the impact of **avoided FBD illnesses**.

3.3.1 Calculating risk ratios of FBD burden

Risk ratios of foods implicated in FBD are derived from two large, comprehensive national studies in the USA and UK (Painter et al., 2013; Tam et al., 2012). As already indicated in Chapter 2.3, we were able to find only one small study from India, by Sudershan et al. (2014). The study was conducted in Hyderbad and is labelled Hyderabad. Next to that, a biological based approach described in the *Bad Bug* Book (Food and Drug Administration, 2012) was included as a fourth assessment method. Most recently, a fifth assessment became available (Hoffmann et al. 2017), in which the FERG group of the World Health Organization uses judgments of 73 international experts to estimate the FBD burden, including expert attribution for the SEAR region However, only a subset of hazards were assessed. These methods are briefly summarized below:

- *Hyderbad*: one small study attributing FBD to different foods in Hyderbad (Sudershan, 2014),
- *Painter*: a national study in USA with strong methodology attributing FBD to different foods (Painter, 2013),
- *Tam*: a national study in UK with strong methodology attributing FBD to different foods (Tam et al., 2012),
- *BadBugs*: a global study attributing FBD to different foods based on biological principles (Food and Drug Administration, 2012)
- *WHO Experts*: a regional expert based study (Hoffmann et al., 2017)

The attribution of FBD burden to different foods resulting from the four methods is displayed in Table 9. These shares were used to link total number of FBD illness to various foods. Consequently, food-related number of cases was divided by quantity consumed to derive risk ratios reported in Table 10. Whereas Hyderabad assessment method places the highest share of FBD diseases to milk (43%), the Painter and WHO experts method assign most illnesses to consumption of fruits and vegetables (40%). Compared to that, Tam assessment method is the most sensitive to the consumption of pigs and poultry (57%). Finally, the Bad Bugs method attributes the FBD burden more evenly and the FBD susceptible foods take a comparable share in total FBD burden. It should be also highlighted that we relate FBD burden to average consumption by total population, not accounting for age distribution. It is expected that young children will be disproportionally affected. However, such level of consumption detail is not provided in the type of model (CGE) we are using to obtain the projections.

Table 9: Attribution of FBD diseases to different types of food

Risk Ratios	***Hyderabad***	***Painter***	***WHO Experts***	***BadBugs***	***Tam***
Wheat & grain	7%	5%	0%	4%	2%
Oils & sugar	7%	1%	0%	3%	1%
Fruits & Veg	29%	46%	38%	29%	10%
Other crops	0%	1%	0%	1%	0%
Cattle	0%	7%	13%	8%	19%
Pigs & poultry	14%	21%	35%	26%	57%
Milk	43%	14%	12%	17%	4%
Fish	0%	6%	2%	11%	7%
Total	100%	100%	100%	100%	100%

Source: authors' compilation based on available studies

Table 10: Risk Ratios (Number of FBD illnesses per ton of consumption)

Risk ratios	***Hyderabad***	***Painter***	***WHO Experts***	***BadBugs***	***Tam***
Wheat & grain	0.03	0.02	0.00	0.02	0.01
Oils & sugar	0.14	0.01	0.00	0.05	0.02
Fruits & Veg	0.16	0.25	0.21	0.16	0.05
Other crops	0.00	0.28	0.00	0.38	-0.02
Cattle	0.00	2.04	4.10	2.56	5.83
Pigs & poultry	2.94	4.36	7.19	5.44	11.68
Milk	0.50	0.16	0.14	0.20	0.05
Fish	0.00	0.97	0.26	1.78	1.08
Total	**0.18**	**0.18**	**0.18**	**0.18**	**0.18**

Source: Computed based on shares in Table 9 and MAGNET consumption data in 2011

3.3.2 Calculating labour supply shocks

We make use of the FBD burden estimates per capita provided by ILRI (Table 11), defined separately for children below 5 and adults (5 and above). There is a remarkable difference in the FBD burden with children being much more affected than adults. It is important to take this distinction into account when computing the shocks to avoid overestimation of impact of FBD on the labour supply.

Table 11: FBD burden per 100,000 by population group

Cases per 100,000	**Children**	**5 and above**
Diarrhoea	30,923	3,974
Hep A	938	556
Ascaris	1,832	106
Salmonella typhi	506	218
S. paratyphi	116	50
Toxoplasma	264	107
Other	498	264
Total	**35,077**	**5,275**

Source: ILRI estimate

Using the incidence of FBD we calculate the total number food-borne disease illnesses in the economically active group of population (Table 12). In doing so, we rescale population estimates to be in line with our dataset6. To establish the number of economically active people we use the GTAP migration database (Özden 2011) which provides estimates on the number of skilled and unskilled people in India, indicating that only about 40% out of the total population is active as part of the labour force. Using the FBD burden for the adults category, total number of FBD cases attributed to the working population is about 26 million out of 100 million of total cases.

[6] The GTAP database on which MAGNET is based only holds the value of labour, e.g. the total wages earned by labour type, and the total population in number of people without age distinctions. We thus need additional data sources to translate the FBD incidence into labour supply shocks.

Table 12: Total FBD burden in economically active group of population

	Active labour force	Total
Share in total population	39%	100%
Population (million)	491	1,247
Total FBD cases	**25,900,833**	**100,437,489**

Source: Özden 2011, author's calculations

The following step is to estimate the FBD burden in the reference scenario describing the situation in 2030. For this we compute risk ratios indicating the number of people that fall ill per unit of food consumption. The risk ratios are obtained by first splitting the total number of FBD cases over food items using the alternative attribution shares from the different assessment methods (Table 10). Using these food-related FBD risks the total FBD burden can be distributed over each household group7 based on the share of each household in total consumption of the respective food. Assuming FBD risks constant over time, the number of FBD cases in 2030 is computed by multiplying risk ratios with new consumption levels obtained from the Reference Case scenario projections. Table 13 shows that the number of cases in 2030 might rise from 100 million up to 170 million depending on the assessment method. This means that about 10% of population would fall ill due to food-borne diseases by 2030.

Table 13: Attribution of total FBD cases to household group in 2030 by assessment method

		Hyderabad	Painter	BadBugs	Tam
Rural	1st quintile	2,649,329	3,256,593	3,224,775	2,901,289
	2nd quintile	8,552,297	10,371,193	10,708,489	10,264,383
	3rd quintile	25,724,031	29,885,992	31,834,241	33,038,506
	4th quintile	18,788,989	20,383,550	21,934,028	24,104,433
	5th quintile	17,043,597	17,649,884	18,416,863	20,343,791
Urban	1st quintile	2,745,419	3,472,242	3,275,640	2,830,898
	2nd quintile	8,776,041	10,558,839	10,636,981	10,386,892
	3rd quintile	24,546,168	26,772,223	27,551,684	29,615,055
	4th quintile	20,121,596	20,168,608	20,979,817	23,481,128
	5th quintile	19,535,515	19,189,613	19,525,720	20,931,580
Total		**148,482,984**	**161,708,736**	**168,088,239**	**177,897,954**

Lacking information on the consumption pattern by age category as well as the demographic composition of the households we have to assume that there is no difference between consumption related risk ratios for the total population and economically active population. We then derive the number of FBD cases per household for the economically active population using the share of FBD of work force divided by total FBD (about 26%). Table 13 shows that for instance, using the BadBugs method, the total number of FBD

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7 MAGNET distinguishes 5 rural an 5 urban household groups, these are ranked from poor to rich with HH1 being the poorest and HH5 the richest in each location.

illnesses in 2030 is expected to reach 168 million while Table 14 shows that only 43 million of these illnesses can be attributed to the economically active population.

Table 14: Attribution of FBD cases of the working population to household groups in the Reference Case

		Hyderabad	Painter	BadBugs	Tam
Rural	1st quintile	683,209	839,811	831,605	748,185
	2nd quintile	2,205,468	2,674,525	2,761,506	2,646,981
	3rd quintile	6,633,717	7,707,004	8,209,418	8,519,974
	4th quintile	4,845,307	5,256,513	5,656,350	6,216,054
	5th quintile	4,395,205	4,551,554	4,749,343	5,246,259
Urban	1st quintile	707,989	895,422	844,723	730,032
	2nd quintile	2,263,167	2,722,915	2,743,066	2,678,573
	3rd quintile	6,329,969	6,904,024	7,105,032	7,637,134
	4th quintile	5,188,960	5,201,083	5,410,278	6,055,316
	5th quintile	5,037,821	4,948,620	5,035,295	5,397,839
Total		**38,290,811**	**41,701,470**	**43,346,617**	**45,876,348**

There are two channels through which food-borne illnesses affect labour in the economy: i) direct reduction of labour supply due to morbidity and ii) reduction in labour productivity due to illness. To quantify the shocks of labour supply due to morbidity, a case fatality ratio is computed from ILRI data. A case fatality ratio indicates the number of deaths per FBD case (see Table 15). Using the ratio for adults, number of FBD illnesses are translated to the number of deaths shown in Table 16. Between 58 thousand up to 70 thousand deaths annually could be expected from FBD diseases, depending on the assessment method used, with notable differences across the household groups.

Table 15: FBD indicators by age group

	All ages	Five and above
FBD Deaths per 100,000	10	8
FBD cases per 100,000	8,591	5,275
Case fatality ratio	0.12%	0.15%

Table 16: Expected FBD related deaths in the economically active population by household group

		Hyderabad	Painter	BadBugs	Tam
Rural	1st quintile	1,036	1,274	1,261	1,135
	2nd quintile	3,345	4,056	4,188	4,014
	3rd quintile	10,061	11,688	12,450	12,921
	4th quintile	7,348	7,972	8,578	9,427
	5th quintile	6,666	6,903	7,203	7,956
Urban	1st quintile	1,074	1,358	1,281	1,107
	2nd quintile	3,432	4,130	4,160	4,062
	3rd quintile	9,600	10,471	10,775	11,582
	4th quintile	7,870	7,888	8,205	9,183
	5th quintile	7,640	7,505	7,636	8,186
Total		**58,071**	**63,244**	**65,739**	**69,576**

In order to convert the number of FBD deaths to a labour supply shock for MAGNET, we need to know the number of skilled and unskilled people by household group. Using the share of skilled and unskilled people in total labour from the GTAP Migration database and accounting for urbanization trends, we can allocate total work force between skill type and location. This allows calculation of an annual wage as a division of labour income from the GTAP database by the number of persons (Table 17).

Table 17: Labour endowments by skill type and location in the 2030 Reference Case

	Unskilled			Skilled		
	Rural	*Urban*	*Total*	*Rural*	*Urban*	*Total*
People (million)	299	195	493	65	43	108
Labour income (million USD)	787,589	480,592	1,268,181	432,013	673,801	1,105,814
Annual Wage (USD)	2,638	2,466	2,570	6,618	15,815	10,250

Consequently, we can derive the number of skilled and unskilled people in each household group by dividing labour income of each household by the respective wage that is skill and location specific. Expressing the FBD deaths (Table 16) as a share of the household labour force, we obtain a labour shock that is implemented in MAGNET. Table 18 shows that the average gain of labour force due to avoided FBD deaths is only about 0.01%. There are however considerable differences with the biggest burden being faced by the richest groups of mostly urban households resulting from both a higher consumption per capita and consumption of products with a higher risk of FBD). This means that in the presence of a well-established food safety system, it will be the richer households who would benefit the most.

Table 18: Labour supply shock due to avoided FBD deaths in economically active group of population

		Hyderabad	Painter	BadBugs	Tam
Rural	1st quintile	0.005%	0.006%	0.006%	0.005%
	2nd quintile	0.005%	0.006%	0.007%	0.006%
	3rd quintile	0.006%	0.006%	0.007%	0.007%
	4th quintile	0.013%	0.014%	0.015%	0.017%
	5th quintile	0.016%	0.016%	0.017%	0.019%
Urban	1st quintile	0.009%	0.011%	0.010%	0.009%
	2nd quintile	0.009%	0.010%	0.011%	0.010%
	3rd quintile	0.008%	0.009%	0.009%	0.010%
	4th quintile	0.020%	0.020%	0.021%	0.023%
	5th quintile	0.024%	0.024%	0.024%	0.026%
Total		**0.010%**	**0.011%**	**0.011%**	**0.012%**

We also adjust the household population size for the number of avoided FBD deaths. Although total population does not have direct economic impact in MAGNET model (this impact channels through the labour supply impact by household type), it is important for calculating per capita variables such as individual utility, GDP per capita, etc. Table 19 shows the changes in household population size through avoided deaths attributed to FBD illnesses.

Table 19: Household population size shocks due to avoided total FBD deaths

		Hyderabad	Painter	BadBugs	Tam
Rural	1st quintile	0.003%	0.004%	0.004%	0.004%
	2nd quintile	0.005%	0.007%	0.007%	0.006%
	3rd quintile	0.008%	0.009%	0.010%	0.010%
	4th quintile	0.012%	0.013%	0.014%	0.015%
	5th quintile	0.021%	0.022%	0.023%	0.026%
Urban	1st quintile	0.005%	0.007%	0.006%	0.005%
	2nd quintile	0.008%	0.010%	0.010%	0.010%
	3rd quintile	0.012%	0.013%	0.013%	0.014%
	4th quintile	0.019%	0.019%	0.020%	0.023%
	5th quintile	0.038%	0.037%	0.038%	0.040%
Total		**0.011%**	**0.012%**	**0.013%**	**0.014%**

3.3.3 Calculating morbidity related labour supply shocks

The second channel through which FBD affects the labour supply is via absence at work due to illness. For estimating the associated labour supply shock, we use an ILRI estimate of the number of years lived with disability. Expressing this per case, on average, there are about 3.5 days of being sick when falling ill from food-borne disease (Table 20).

Table 20: Years lived with disability due to FBD

	All ages	Five and above
Years lived with disability per 100,000	83	54
FBD Illnesses cases per 100,000	8,591	5,275
Disability days per FBD case	3.5	3.7

Using the estimated number of FBD cases in 2030 for the economically active population, the share of disability days out of total working days of the economically active population is calculated (there are about 250 working days in India according to Working Days Online, 2017). As seen in Table 21, the share reaches about 0.1% of working time. Therefore, it can be expected that in the presence of a well-functioning food safety system, labour supply would be on average 0.1% higher. The total labour supply shock implemented in MAGNET is a sum of the mortality and morbidity labour supply shocks.

Table 21: Proportion of days not worked due to FBD burden in 2030 by assessment method

	Hyderabad	Painter	BadBugs	Tam
Total	0.095%	0.104%	0.108%	0.114%

3.3.4 Calculating the health care costs shock

Another economic channel via which food-borne diseases affect the economy is health care expenditures. We use IRLI input on costs of treatment for specific type of FBD illnesses to calculate unit health care costs per FBD case. Again, it is important to make a distinction between costs accruing to treatment of children and adults. Based on ILRI estimates, the cost of FBD illness is between 19 and 40 USD per case, depending on the age (Table 22). In order to estimate the proportion of saved health costs by 2030, unit health care costs are expressed in 2030 prices using growth of prices of public services sector (of which health care is part). Total health care costs in 2030 are then estimated by multiplying expected number of FBD cases in 2030 in each population group by these unit health care costs.

Table 22: Unit FBD health care costs in 2011 and 2030 by age group

	Children	5 above
Costs per case in USD in 2011 prices (ILRI)	19	40
Costs per case in USD in 2030 prices (MAGNET)	28	60

Table 23 shows that total FBD costs may reach between 7.0 – 8.4 billion USD in 2030, which represents a significant increase from the 3 billion USD estimated in 2011. Given that in MAGNET the health care sector is part of a large aggregate public services sector, we need to estimate the value of total health care sector as a proportion of the sector of public services. For this we use the WHO data indicating that in India the health care sector comprises 4% to total GDP and it accounts for about 34% of total public services expenditures. Assuming no structural change in the government services we apply these shares to the 2030 projection to determine health care sector expenditures, which reach about 261 billion USD. The share of health care costs saved due to avoided FBD illnesses then ranges between 2.7% - 3.2% (depending on the FDB assessment method). It is interesting to note that the share may eventually decline by 2030 as total public sector expenditures are expected to grow more quickly than the number of FBD illnesses, even corrected for inflation.

Table 23: Estimated health care costs and proportion from total (values in million USD)

	2011	2030			
		Hyderabad	Painter	BadBugs	Tam
Public services sector total	233,694	759,971	759,971	759,971	759,971
Health sector	80,316	261,188	261,188	261,188	261,188
FBD costs	3,089	6,970	7,591	7,890	8,351
Share FBD costs (%)	4%	2.7%	2.9%	3.0%	3.2%

3.4 Key contributions & limitations of the macro-economic methodology

In this section, the methodological tool MAGNET was introduced. Being an economy-wide model, MAGNET enables to capture the linkages between labour markets, households, firms and government and is thus well positioned to model the macro-economic impacts of avoided FBD illnesses and health care cost savings. MAGNET is also able to trace detailed food consumption of household groups which is important for estimating the expected food-disease burden in the future.

It is important to keep in mind that there are various assumptions that drive the FBD projections and the scenario results. For estimating household food consumption in the reference case, GDP growth, population growth and urbanization trends were incorporated in MAGNET. Accounting for these factors has an important impact on households' future consumption but is of course not set in stone but determined by the dynamic development unfolding in India in the near future.

For estimating the expected number of food-borne diseases in the reference case, risk ratios relating FBD burden per unit of consumption were calculated using four different assessment methods, providing an upper and lower bound of impacts. Due to the lack of detail on the demographic structure of consumption, we have to assume that risk ratios are uniform across age group. We also assume that risk ratios, deaths and sickness per case remain constant over time. This means that the expected FBD burden is driven purely by consumption changes, keeping the probability of falling ill unchanged.

Understanding the future FBD burden enables us to calculate the corresponding labour supply increase and health care costs savings when FBD burden would be reduced. The resulting shock magnitudes are as follows (values in brackets are based on the Tam method, representing the upper bound of the ILRI estimates):

- **Mortality related labour supply increase (+ 0.012%, corresponding to 70 thousand avoided deaths):** Labour supply is increased by the avoided FBD deaths in the group of economically active population ---> *affects labour markets and household wage income*;
- **Morbidity related Labour productivity increase (+0.11%, corresponding to 3.7 disability days per case)**: Labour supply is increased by the share of avoided disability days out of total

working days of the economically active population ---> *affects labour markets and household wage income*;

- **Total population increase (+ 0.014%, corresponding to 200 thousand avoided deaths):** Total population of India is increased by the avoided FBD deaths (including children) ---> *affects per capita income and consumption*;
- **Health care savings (+ 3.2%, corresponding to 8 billion USD):** Total factor productivity of the sector of public services is increased by the expected reduction of health care costs associated with treating FBD related illnesses ---> *affects government and households expenditures and savings.*

The following two chapters contain results of the application of MAGNET model. Chapter 4 provides an outlook on the FBD burden if no investments in food safety are made and chapter 5 quantifies potential economic impacts of avoiding the FBD burden via labour supply and health care shocks presented above.

Finally, it is important to note that the macro-economic approach only captures the benefits that are monetarized. However, investments in food safety have also positive externalities that do not go through markets such as improvements in wellbeing. Therefore, not all benefits to the Indian society are captured by the economic assessment in this study.

4 Outlook on the FBD burden in India in 2030 – Reference Case

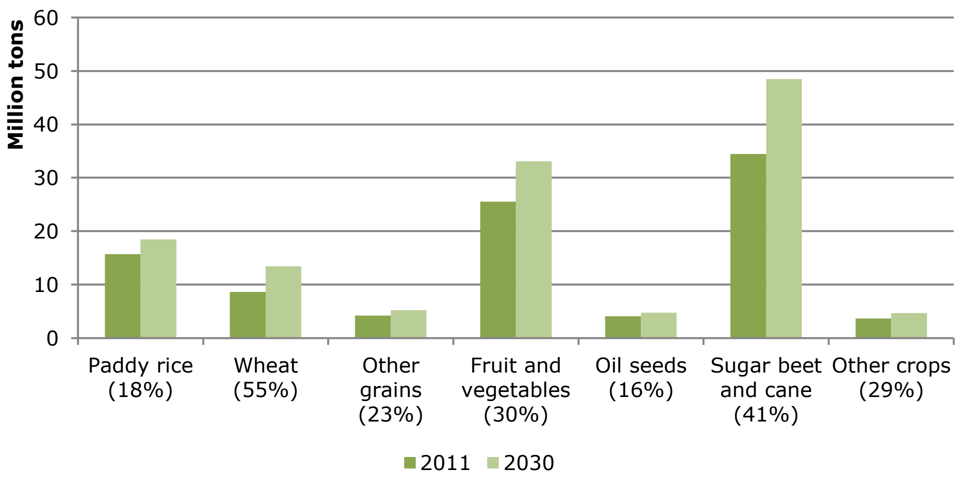
Investments in food safety improvements will not materialize immediately and therefore there is a need to take FBD developments with no change in policies into account. To derive an outlook to 2030 for the FBD burden we use MAGNET, a global economy-wide or CGE model, which includes the development of the Indian economy at national level[8]. The starting point for the analysis is year 2011, which is the most recent year for which the MAGNET database is available. The FBD indicators are then updated from 2010 to 2011 taking into account the respective population size.

Assuming no changes in policies (business-as-usual scenario) we create an outlook on the global and India's economy in 2030 by accounting for two key macro-economic drivers: population growth and GDP. We also account for an exogenous yield improvement in agriculture based on a combination of FAO and Netherlands Environmental Assessment Agency expert assessments. India's GDP growth at 212% compared to 2011 is expected to outpace global GDP growing by 86%. India's already sizeable population, however, will also grow faster at 22% than the global population at 19%. Combining these two trends, the income per capita in India is projected to grow from 1,505 to 3,839 in the 2011-2030 period (constant 2011 US$). More than doubling the per capita income has significant impacts on the Indian economy. We will first explore key macro-economic implications focussing on the primary agricultural sectors in India, before turning to their impact on the FBD outlooks for 2030 at national level. The trends at the national level may obscure different developments across household groups. We therefore take a closer look at household level developments in consumption patterns and associated FBD burden at the end of this chapter.

4.1 India's primary agricultural sector in 2030

Starting from a meagre 4 dollar a day average per capita income in 2011 the projected increases in per capita income have a strong impact on demand for food. Figure 6 presents the production of food crops in India, with in most cases growth rates exceeding the population growth of 22%.

Figure 6: Production of food crops in India and growth rates from 2011-2030



Source: MAGNET simulations

[8] See chapter 2 for a description of the MAGNET model and database as well as the scenario drivers.

A major constraint on expanding India's production is the availability of land. In 2011, already 84% of the potentially available land is used for agriculture. While we do account for increases in productivity of land, labour and other inputs, bringing additional land into production will be costly[9]. The demand driven push to increase food production expands the agricultural area to 90% of the available land, and this increased scarcity of land is reflected by a tripling of the land price. The increase in income stimulates not only demand for food, but also for other commodities, reflecting a structural change in the economy with rising incomes (Table 24). As a result, wages increase as well, with rates ranging between 113% (rural skilled labour) to 151% for urban unskilled labour (employed in manufacturing and services, which increase in relative importance due the increased income levels).

Table 24: Value-added by sector (% of total value-added)

		2011	*2030*
Food		**20**	**16**
	Primary production	17	15
	Processed food	3	1
Manufacturing		**28**	**31**
	Low-tech industry	23	24
	High tech industry	5	6
Services		**53**	**53**
	Government services	12	13
	Other services	41	40

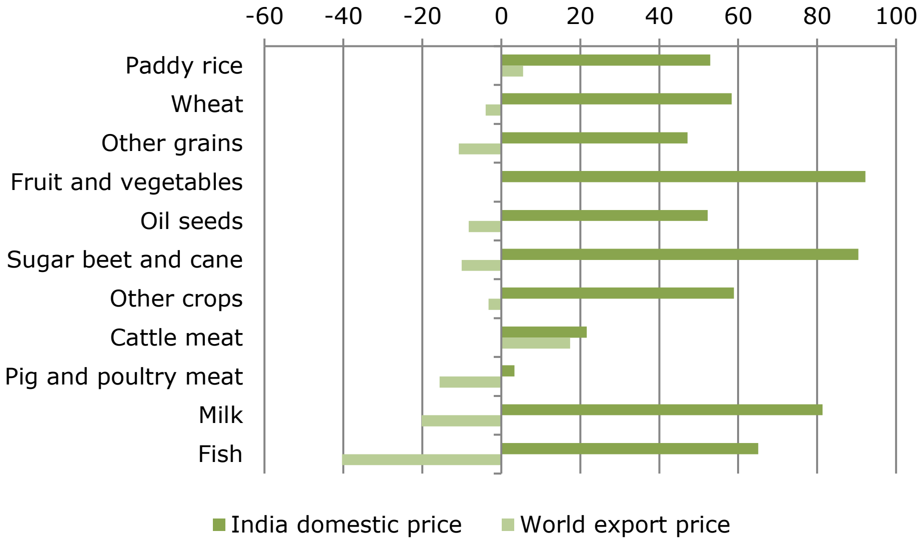
Source: MAGNET simulations

The rising costs of land and labour, key inputs for agriculture, are reflected in increased prices in India's domestic market for primary commodities (Figure 7). For most commodities, the price developments in India are both much stronger (prices of primary commodities will grow by about 60%) and in the opposite direction of the development in the aggregate world export prices (about 10% decline). The expected deflation of food prices globally is not easily transmitted into the domestic market. This is because domestic and imported commodities are imperfect substitutes in MAGNET, due the variety differences within the rather aggregate commodity definition in MAGNET and because trade shares are very small (Figure 8). With regard to the former, for example, the composition of the fruit and vegetable sector will vary more across countries across the globe and thus has a lower substitution elasticity between domestic and imported commodities (1.85) than a more uniform commodity like rice (5.05). These substitution elasticities moderate the demand for imports and thus the extent to which world prices are connected to domestic prices.

The contrasting price developments in Figure 7 signal a loss in competiveness of India's agricultural production. By 2030, India will turn to a net importer of food, which is a development projected for most developing countries (Alexandratos and Bruinsma, 2012). Combined with rising domestic demand, the share of exports in primary production will decline from 2.6 to a tiny 0.5% in 2030 (Figure 8). One potential benefit from the increase of food safety in India would be to enhance its export opportunities. In the context of India's loss in comparative advantage it seems unlikely that such increased export opportunities would be sufficient to counteract the price developments to an extent that visible gains are to be expected in the aggregate commodity representation in MAGNET, although specific products may be gain from an increased food safety standing in India.

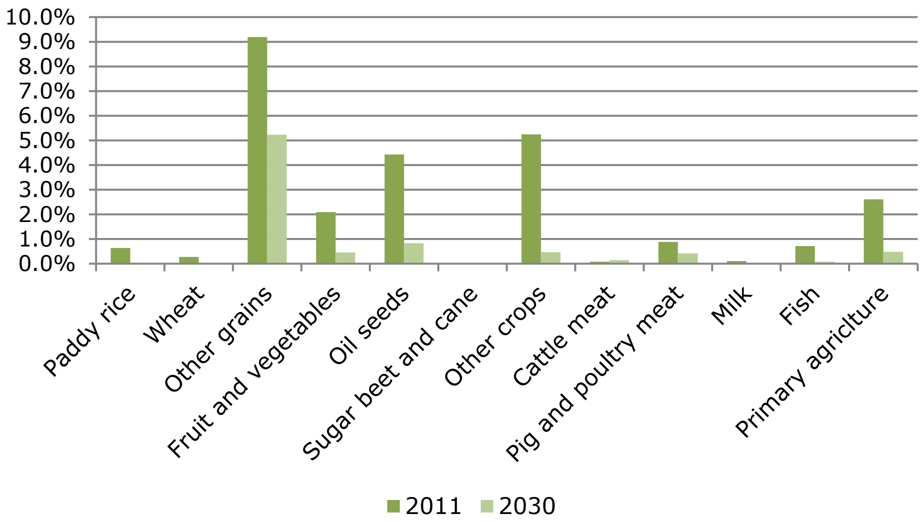
[9] MAGNET includes endogenous land supply modelled through a land asymptote, for a country like India close to the land asymptote expanding agricultural land results in rapid increases in land prices. This captures the empirical evidence that production expands first in easily accessible areas, bringing in the last available parts of land thus comes at a high cost. In general this reflects that land is scarce in India and higher food demand does not in general lead to an increase in land use but to higher land prices.

Figure 7: Change in domestic prices in India and world export prices (%, 2011-2030)



Source: MAGNET simulations

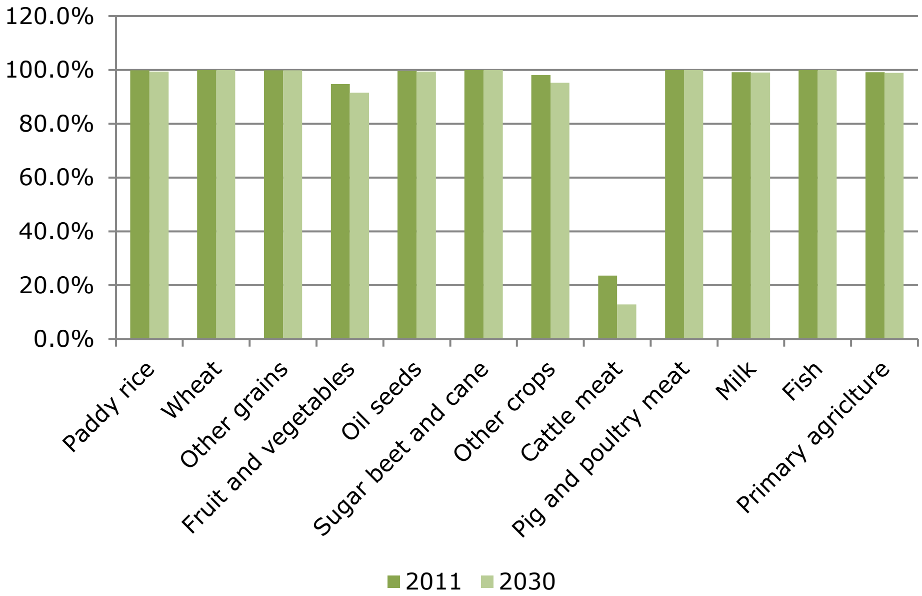
Figure 8: Share of primary agricultural exports in domestic production in India (%)



Source: MAGNET simulations

Despite the loss in competitiveness the private consumption of primary commodities remains almost fully sourced from domestic production (Figure 9) (explanation of the underlying mechanisms driving behaviour of consumers in MAGNET CGE model is provided in Box 2 above). The only commodities where imports play visible roles is fruit and vegetables and cattle meat. Changes in the food safety of India producers will thus benefit India consumers. This strong reliance on domestic products by households also implies that we do not expect a lot of impact from an increased preference for imported goods, in addition to a lack of empirical evidence on persistent shifts towards imports in response to food safety concerns (see Box 1 above).

Figure 10: Share of domestic production private consumption (%)

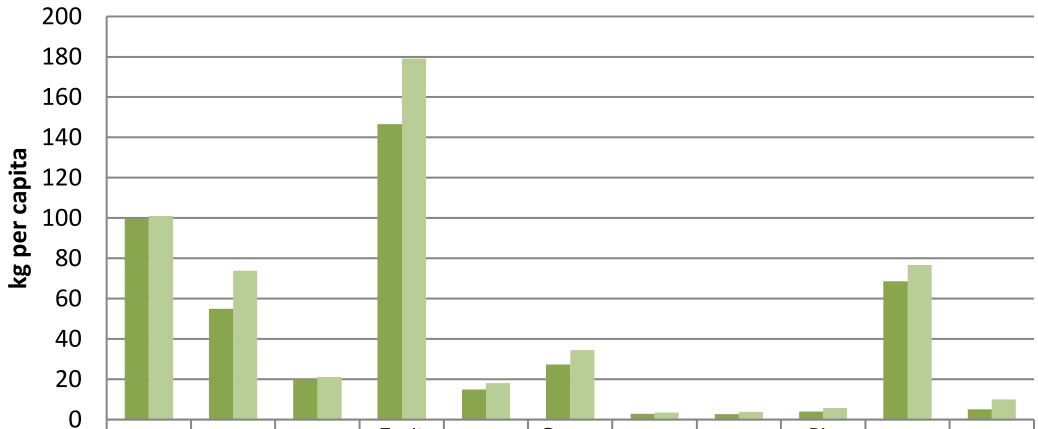


Source: MAGNET simulations

4.2 Decomposing India's FBD burden in 2030

To be able to provide an outlook on India's FBD burden by 2030 we combine the consumption of FBD susceptible foods in 2030 with the current FBD risk ratios attributed to different food types. Assuming the risk ratios remain constant, changes in the FBD burden are thus determined by the interplay between population growth (increasing the number of people) and the demand pattern of these people (driven by income growth and urbanization).

Figure 11: Average private consumption in India of primary products



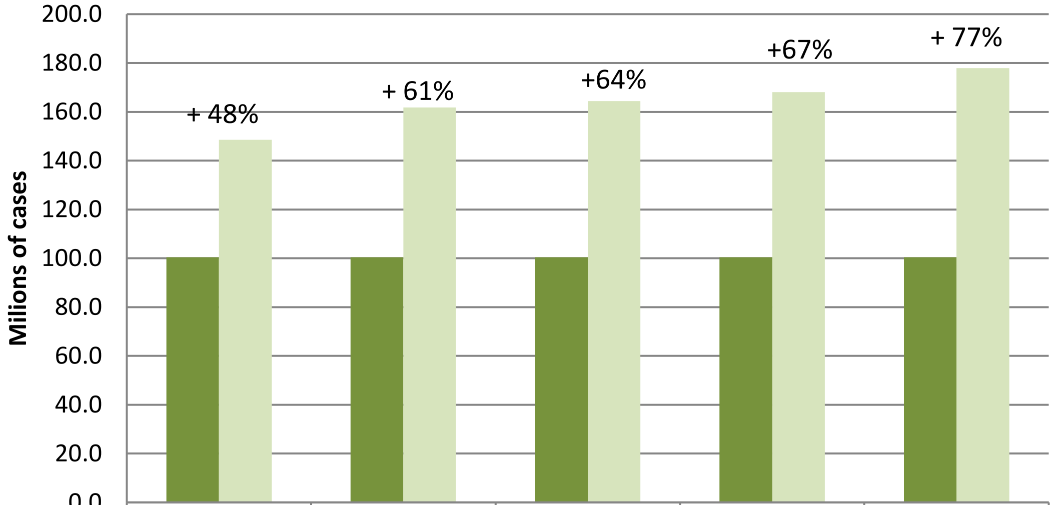
	Paddy rice	Wheat	Other grains	Fruit and vegeta bles	Oil seeds	Sugar beet and cane	Other crops	Cattle meat	Pig and poultry meat	Milk	Fish
2011	100	55	20	147	15	27	3	3	4	69	5
2030	101	74	21	179	18	34	3	4	6	77	10

Source: MAGNET simulations

The income effects of higher land and labour prices (these increase the households' income) outweigh the expenditure effect of higher food price, reflected by an increase in per capita quantities of primary commodities between 2011 and 2030 (Figure 11). These projections are in line with FAO (Alexadratos and Bruinsma, 2012) which expects meat consumption to rise to 9kg by 2030 and up to 18kg in 2050 (although large parts of the Indian population have limited preferences for meat consumption in their diets). As for cereals and fruits and vegetables, total projected quantity consumed is in line with values reported in the Vision 2030 of the Indian Council of Agricultural Research.

Increasing consumption implies increasing FBD risks, all other things being equal. Combined with the population increases the result is a strong increase in the number of FBD cases between 45 to 77 percent (Figure 12). These different methods can be understood as an interval of expected increase of FBD illnesses with the projections based on WHO Experts serving as a median. Referring to Tables 9 and 10, the differences are caused by differences in food-attributed FBD burden. Whereas the Hyderabad assessment method places the highest share of FBD diseases to milk (43%), the Painter method assigns most illnesses to consumption of fruits and vegetables (46%). Compared to that, Tam assessment method is the most sensitive to the consumption of pigs and poultry (57%). Finally, the Bad Bugs method attributes the FBD burden more evenly and the FBD susceptible foods take a comparable share in total FBD burden. It should be also highlighted that we relate FBD burden to average consumption by total population, not accounting for age distribution. It is expected that young children will be disproportionally affected. However, such level of consumption detail is not provided in the type of model (CGE) we are using to obtain the projections.

Figure 12: FBD cases in India by assessment method



	Hyderabad	Painter	WHO Experts	BadBugs	Tam
2011	100.4	100.4	100.4	100.4	100.4
2030	148.5	161.7	164.4	168.1	177.9

Source: MAGNET simulations

Table 25 reports the expected number of FBD cases per household group, distinguished by rural/urban location and income group. Clearly, there are considerable differences across the household types. Particularly lower income urban households will face the strongest increase of FBD burden (between 100 – 150% increase compared to 2011), the highest number of cases will be expected in the middle income groups.

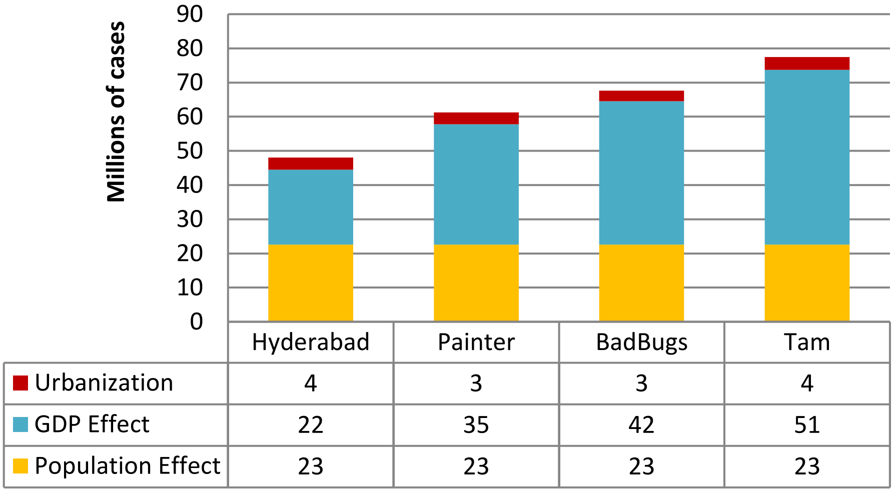
Table 25: Number of FBD cases in million per household group and assessment method

Household groups		Hyderabad			Painter			BadBugs			Tam		
		2011	**2030**	**%**	**2011**	**2030**	**%**	**2011**	**2030**	**%**	**2011**	**2030**	**%**
	1st quintile	1.8	2.6	47%	2.1	2.8	36%	1.9	3.2	66%	1.7	2.9	66%
	2nd quintile	5.8	8.6	48%	6.4	9.5	49%	6.2	10.7	73%	5.8	10.3	76%
	3rd quintile	18.3	25.7	41%	19.0	29.2	54%	19.1	31.8	66%	19.1	33.0	73%
	4th quintile	14.0	18.8	35%	13.6	21.1	55%	13.9	21.9	57%	14.3	24.1	68%
Rural	**5th quintile**	15.7	17.0	9%	15.2	18.6	22%	15.5	18.4	19%	15.8	20.3	28%
	1st quintile	1.3	2.7	109%	1.6	3.1	101%	1.4	3.3	135%	1.2	2.8	143%
	2nd quintile	4.3	8.8	105%	4.7	10.2	117%	4.5	10.6	139%	4.1	10.4	152%
	3rd quintile	13.6	24.5	80%	13.7	27.9	104%	13.5	27.6	104%	13.3	29.6	122%
	4th quintile	12.2	20.1	64%	11.4	21.8	90%	11.6	21.0	81%	11.9	23.5	98%
Urban	**5th quintile**	13.5	19.5	44%	12.8	20.1	57%	12.9	19.5	52%	13.1	20.9	60%
Total		**100.4**	**148.5**	**48%**	**100.4**	**164.4**	**64%**	**100.4**	**168.1**	**67%**	**100.4**	**177.9**	**77%**

Source: MAGNET simulations, Note: Results for WHO Experts method are in between Painter and BadBugs.

Figure 13 decomposes the additional increase in FBD burden into the three drivers per each assessment method. Where population and urbanization have about the same contribution across methods, 23 and 4 million cases respectively, the GDP effect accounts for the largest difference across the methods (up to 50 million additional cases). This clearly shows that increased income provokes significant change in the food consumption pattern. Tam method reports the highest GDP effect, which is related to the significant increase of meat consumption by 2030, driven by income growth (meat consumption per capita is expected to grow by almost 50% and fish consumption might even double).

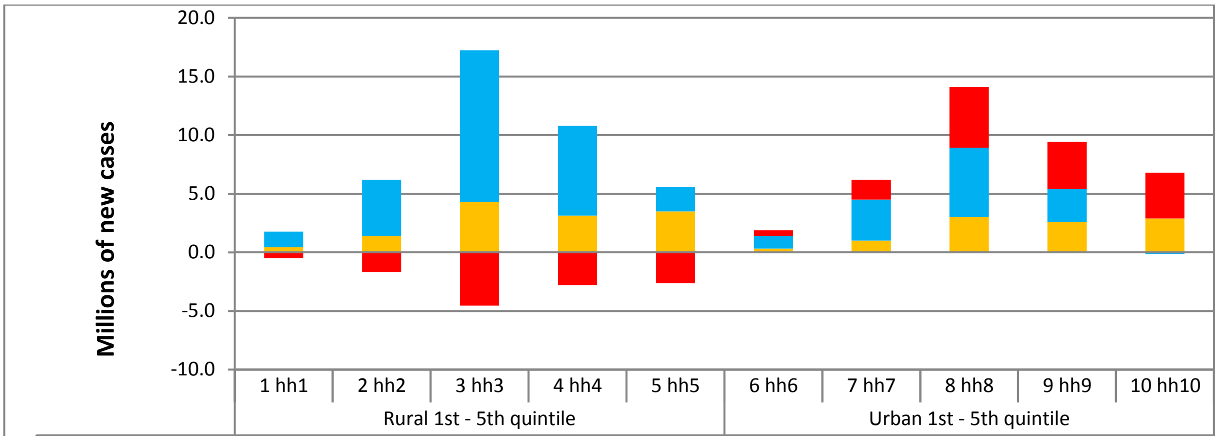
Figure 14: Decomposing of new FBD cases in 2030 vs 2011 for key drivers, by assessment method



Source: MAGNET simulations, Note: Results for WHO Experts method are in between Painter and BadBugs.

Although on the aggregate level, the role of urbanization does not seem to be crucial in contributing to the FBD burden, zooming into the situation of the household groups reveals that urbanization may produce important changes in consumption and related FBD burden. This is visible in Figure 15 which shows the contribution of each factor to FBD burden per household group, using the Bad Bugs assessment method (being the most representative[10]). Clearly, for rural households, FBD burden will be driven mostly by GDP growth. As for urban households, migration to cities increasing their relative size in the population is an important factor contributing to the susceptibility of FBD illnesses. Regarding the richest urban households, GDP effect disappears as additional income does not lead to higher food consumption, rather, is it spent on other, more luxurious type of goods.

Figure 15: Decomposition of FBD Burden difference in 2030 vs 2011 – BadBugs Assessment method



	1 hh1	2 hh2	3 hh3	4 hh4	5 hh5	6 hh6	7 hh7	8 hh8	9 hh9	10 hh10
	Rural 1st - 5th quintile					Urban 1st - 5th quintile				
Urbanization effect	-0.5	-1.7	-4.5	-2.8	-2.6	0.5	1.7	5.1	4.0	3.9
GDP Effect	1.3	4.8	12.9	7.7	2.1	1.1	3.5	5.9	2.8	-0.2
Population Effect	0.4	1.4	4.3	3.1	3.5	0.3	1.0	3.0	2.6	2.9

Source: MAGNET simulations

4.3 Expected developments in FBD burden with no change in policy

Given the expected significant economic growth between 2011 and 2030, population growth and urbanization, household incomes are expected to rise as a result of growing factor incomes (land rents and wages). This will be reflected in higher consumption of food, particularly fruits, vegetables and meat, which will result in a significant increase of FBD illnesses**. The number of FBD cases** is expected to rise **from 100 million to 150 – 177 million** in 2030 compared to 2011. This means that by 2030, **one out of 9** people on average fall sick, up from one out of 12 in 2011. However, rich rural and urban households will be disproportionally more affected than others, where **every third person could fall sick** from food diseases.

Decomposition of various drivers show that the growing **FBD burden is attributed mostly to the GDP growth**, followed by population growth. The GDP effect provokes a significant increase of meat consumption by 2030, which is a highly susceptible food category for infectious food diseases. Next to that, **urbanization plays an important role for certain types of households.**

Due to rising domestic demand and food prices, the negligible share of exports will decline further. Given the limited role of primary agrarian foreign trade in the Indian economy, the **expected economic benefits of an improved food safety system will come from labour productivity and health improvements**. Their contributions were investigated in the scenario assessment presented in the following chapter.

[10] The Bad Bug method is based on the most comprehensive set of food hazards as compared to the other three methods that attribute most burden to a particular food category relevant in the geographical region.

It is important to note that other factors may radically effect the trajectory of FBD in India; for example, there is a group of foodborne pathogens that are strongly associated with low income settings. If average income increases, they become less important, presumably because of a general increase in hygiene. Scenario analysis could help account for some of these possibilities.

5 Potential economic impact of a reduced FBD burden – scenario analysis

Having established the expected FBD burden by 2030 if there are no changes in food safety in India, we now turn to exploring the potential economic benefits of food safety improvements. The analysis is done in two steps to disentangle impacts through increased labour supply and a reduction in health costs.

5.1 Impact of increased labour supply due to avoided FBD illness

In this section, the impact of increased labour supply resulting from avoided mortality and morbidity of food-borne diseases is analysed. The results are reported for the two assessment methods that are the lowest (Hyderabad) and the highest (Tam). These estimates can thus be taken as the lower and upper bound of the expected food safety impacts.

The impact through the labour supply channel can be best explained when looking at the chain reaction following the initial shock. As shown in Table 26, the richer urban households are mostly prone to fall ill due to the food-borne disease risk and therefore, they can benefit most from a situation of a well working food safety system. Their higher susceptibility to FBD is due to their consumption pattern, as these are computed based on risk ratios attributed to food groups (see above).

Table 26: Labour supply shock per household due to FBD (mortality and morbidity)

		Hyderabad	Tam
Rural	1st quintile	0.05%	0.05%
	2nd quintile	0.05%	0.06%
	3rd quintile	0.05%	0.07%
	4th quintile	0.13%	0.16%
	5th quintile	0.16%	0.19%
Urban	1st quintile	0.09%	0.09%
	2nd quintile	0.09%	0.10%
	3rd quintile	0.08%	0.10%
	4th quintile	0.20%	0.23%
	5th quintile	0.24%	0.26%
Total		**0.095%**	**0.114%**

Lacking further information on who consumes which food within each household group we apply the same shock to all types, skilled and unskilled, of labour. With households varying in their labour endowments, this adds a second layer of variation to the shock resulting in different shocks by labour type at national level (Table 27). Since urban households, who are more prone to FBD, are more endowed with skilled labour than rural households (on average 60% vs 40 %), the labour supply shocks are the highest for skilled labour allocated in urban areas and lowest for unskilled labour in rural areas.

Table 27: Labour supply shock per labour type

	Unskilled		Skilled	
	Rural	Urban	Rural	Urban
Hyderabad	0.08%	0.13%	0.10%	0.14%
Tam	0.10%	0.15%	0.13%	0.16%

In a partial equilibrium model, increased labour supply with a constant labour demand will result in declining wages. In a general equilibrium setting, however, there is a rebound effect as lower wages encourages labour demand so the final wage reduction will be more moderate. Table 28 shows that the corresponding reduction of wages is in range of 0.06% - 0.10%, with the highest drop for the skilled urban labour.

Table 28: Impact of labour supply shock on wages (% change vs Reference Case)

	Unskilled		Skilled	
	Rural	Urban	Rural	Urban
Hyderabad	-0.06%	-0.07%	-0.07%	-0.09%
Tam	-0.08%	-0.09%	-0.09%	-0.10%

The decline of wages positively affects production costs of firms and their competitiveness. The sectors that will gain most are those that have the highest share of labour in production costs, i.e. the labour-intensive sectors. Table 29 shows that the most labour-intensive sector is public services, where the share of labour in total costs is 76%, with a predominant role of skilled labour. The sector of low-tech industry employs the highest share of unskilled labour.

Table 29: Cost structure of firms in the Reference Case

		Primary Agriculture	**Food processing**	**Low-tech industry**	**High-tech industry**	**Public Services**	**Business Services**
Unskilled	Rural	17.01%	6.20%	12.20%	4.11%	5.75%	6.75%
	Urban	0.80%	0.78%	8.23%	2.56%	5.33%	6.53%
Skilled	Rural	0.06%	0.96%	3.31%	0.49%	26.80%	5.11%
	Urban	0.01%	0.25%	5.53%	0.67%	38.45%	8.79%
Total		**18%**	**8%**	**29%**	**8%**	**76%**	**27%**

The impact of the decline in wages on volume of production is displayed in Table 30. As expected, the biggest growth of production is obtained from the sector of public services (the effect of skilled labour wages decline), followed by low-tech industry (the effect unskilled labour wages decline) and business services (combined effect of both skilled and unskilled labour wages).

Table 30: Impact of labour supply shock on production volume (% change vs Reference Case)

	Primary Agriculture	Food processing	Low-tech industry	High-tech industry	Public Services	Business Services
Hyderabad	0.004%	0.003%	0.066%	0.050%	0.084%	0.054%
Tam	0.005%	0.003%	0.078%	0.059%	0.100%	0.065%

The positive growth of production and decline of costs is translated into the development of market prices. Not surprisingly, prices would decline for most of production sectors as a result of lower production costs and higher quantity supplied (Table 31). The exception is the sector of primary agriculture and food processing, where prices would eventually increase. Food prices are expected to grow up to 0.05% compared to the reference case scenario. This development is driven by rising land prices which are very sensitive to any increase in food production due a practical lack of scope for expanding the agricultural area in India, while the agricultural production functions offers limited scope to substitute labour for land. An increase in agricultural labour use fuelled by the lower wages thus increases demand for land, resulting in rising prices of food and subsequently food processing.

Table 31: Impact of labour supply shock on market prices (% change vs Reference Case)

	Primary Agriculture	Food processing	Low-tech industry	High-tech industry	Public Services	Business Services	GDP Deflator
Hyderabad	0.044%	0.028%	-0.020%	-0.007%	-0.056%	-0.010%	-0.014%
Tam	0.051%	0.032%	-0.024%	-0.009%	-0.066%	-0.012%	-0.016%

The labour supply shocks will have repercussions for the incomes of households as well. Again, the magnitude of reaction depends on the share of skilled and unskilled labour in the households' incomes. Table 32 presents the labour share in total household incomes across the ten household groups. There is a remarkable difference in the importance of labour income plays across the different household types. In general, low income households rely for about 80% on their labour income, whereas for the high income households it may be as little as 20% (the highest decile in urban zones).

Table 32: Share of labour income in household income (Reference Case)

	Rural					**Urban**					
	r_hh1	r_hh2	r_hh3	r_hh4	r_hh5	u_hh1	u_hh2	u_hh3	u_hh4	u_hh5	**Total**
Skilled	69%	63%	48%	19%	11%	51%	42%	28%	12%	7%	**25%**
Unskilled	13%	17%	23%	17%	13%	28%	35%	42%	23%	11%	**22%**
Total	**82%**	**80%**	**71%**	**36%**	**23%**	**79%**	**77%**	**70%**	**35%**	**18%**	**48%**

The impact of the labour shock on household income is displayed in Table 33 which shows that lower income households are worse off. Because lower income households are less affected by the FBD burden, the simulated labour supply increase is relatively small and thus does not compensate the decline of wages. Given that wages constitute the most significant part of poor household's income, the total effect is negative (-0.01%). Contrary to that, high income households benefit from the increase of labour supply and increasing land and capital prices with their total income growing by about 0.07%.

Table 33: Impact of labour supply shock on household income (% from Reference Case)

		Hyderabad	Tam
Rural	1st quintile	-0.01%	-0.02%
	2nd quintile	-0.01%	-0.01%
	3rd quintile	0.00%	0.01%
	4th quintile	0.05%	0.07%
	5th quintile	0.05%	0.06%
Urban	1st quintile	0.02%	0.01%
	2nd quintile	0.02%	0.03%
	3rd quintile	0.02%	0.02%
	4th quintile	0.08%	0.09%
	5th quintile	0.07%	0.07%
Total		**0.04%**	**0.05%**

Increased income of households is also reflected in increased spending. Table 34 shows that the highest increase in household demand is for services, followed by industrial output. Food demand is almost unaffected. This is explained by both the demand and supply side - on the demand side, the biggest gain comes from high income households who consume more luxurious goods than food. On the supply side, agriculture becomes relatively less competitive compared to other industries due to rising land prices and the increase in food prices limits the growth of consumption.

Table 34: Impact of labour supply shock on volume of household consumption (% from Reference Case)

	Primary Agriculture	Food processing	Low-tech industry	High-tech industry	Public Services	Business Services
Hyderabad	0.004%	0.004%	0.051%	0.050%	0.073%	0.056%
Tam	0.005%	0.004%	0.061%	0.059%	0.087%	0.066%

5.1 Total impact of avoiding FBD burden (labour shock + health cost savings)

In this section, the health care costs are brought into the scenario analysis with results showing the combined impact of labour supply and health care costs on the Indian economy. The health care savings are implemented as a positive productivity shock in the sector of public services as discussed above. As shown in Table 23, the FBD related health care costs reach between 2.7% - 3.2% of total public services expenditures by 2030. The impact of health care cost savings on production by sector is shown in Table 35. The health care cost savings are almost fully transmitted to an increase of production of public services. Positive spill-over effects are visible for business services and low-tech industry.

Table 35: Impact of combined labour supply and health care shocks on production volume (% from Reference Case)

	Primary Agriculture	Food processing	Low-tech industry	High-tech industry	Public Services	Business Services
Hyderabad	-0.006%	0.006%	0.109%	0.044%	2.172%	0.223%
Tam	-0.007%	0.007%	0.129%	0.053%	2.602%	0.266%

Table 36: Cost structure of sectors in the Reference Case

		Primary Agriculture	Food processing	Low-tech industry	High-tech industry	Public Services	Business Services
Intermediate Consumption	Primary Agriculture	11.5%	72.4%	0.3%	0.9%	0.1%	1.0%
	Food processing	0.2%	2.1%	0.1%	0.3%	0.0%	0.4%
	Low-tech industry	1.2%	1.2%	30.4%	38.2%	0.8%	4.1%
	High-tech industry	1.2%	0.9%	5.2%	27.3%	2.0%	6.2%
	Public Services	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.2%**	**0.4%**
	Business Services	2.1%	6.0%	**14.9%**	11.8%	3.2%	12.5%
Value Added	Land	50.5%	0.0%	0.0%	0.0%	0.0%	0.0%
	Unskilled Labour	17.8%	7.0%	20.4%	6.7%	11.1%	13.3%
	Skilled Labour	0.1%	1.2%	8.8%	1.2%	65.3%	13.9%
	Capital	8.9%	6.1%	16.5%	13.6%	17.3%	47.9%
	Natural Resources	0.0%	0.0%	1.6%	0.0%	0.0%	0.0%
	Fishes	5.3%	0.0%	0.0%	0.0%	0.0%	0.0%

It is interesting to note that public services is not a sector with significant backward or forward linkages (Table 36). This is concluded from the low share of this sector in the intermediate consumption of other sectors. For instance, looking at the high industry sector, 40% of the inputs come from low-tech industry, indicating strong interlinkages between these two sectors, whereas almost no inputs are used from public services. Therefore, the spill-over effect of stimulating the health care sector to the other sectors in the economy does not come from the production side, but rather through consumption. However, it is notable that the sector of low tech industry uses an important part of inputs from business services (this refers to trade, transport, storage, etc.). This may explain why both business services and low-tech industry show jointly an increase in production (next to the fact that both sectors are labour-intensive and profit from reduced labour costs).

Looking at the demand side of the economy, both government and households benefit from the savings in health care costs (Table 37). Whereas nominal income increases only moderately (around 0.1% for government and 0.05% for households), real expenditures increase more notably. This is because of a general decrease of prices which allows households and government to consume more. There is also an increase in savings.

Table 37: Income, expenditures and savings of household and government (% from Reference case)

	Hyderabad		Tam	
	Government	*Households*	*Government*	*Households*
Income	0.10%	0.05%	0.12%	0.06%
Real Consumption Expenditures	1.88%	0.31%	2.25%	0.38%
Real Savings	0.09%	0.10%	0.10%	0.11%

Table 38 shows the impact by household group. For some nominal income even moderately declines, however, in the real terms all households benefit from the new situation, with an increased consumption ranging around 0.3% over all households.

Table 38: Impact of total shock on Household income (% from Reference Case)

		Income		Real Consumption	
		Hyderabad	Tam	Hyderabad	Tam
Rural	1st quintile	0.01%	0.00%	0.24%	0.27%
	2nd quintile	0.00%	0.00%	0.21%	0.25%
	3rd quintile	0.00%	0.00%	0.23%	0.28%
	4th quintile	0.09%	0.11%	0.33%	0.40%
	5th quintile	0.10%	0.12%	0.39%	0.46%
Urban	1st quintile	0.01%	0.00%	0.24%	0.27%
	2nd quintile	-0.01%	-0.01%	0.22%	0.26%
	3rd quintile	-0.03%	-0.04%	0.24%	0.29%
	4th quintile	0.10%	0.12%	0.38%	0.45%
	5th quintile	0.12%	0.14%	0.41%	0.49%
Total		**0.05%**	**0.06%**	**0.07%**	**0.38%**

The income of households is very much affected by what happens in the factor markets. Looking at Table 39, there is a significant drop of wages of skilled labour. This is directly linked to the simulation carried out – by increasing productivity of health care sector, health costs go down. Since skilled labour constitutes the major component of costs in the public care sector (65%, see Table 36), this is immediately reflected in a drop of skilled wages. On the other hand, higher savings in the economy result in increase of investment price and returns to capital go up. Given that the richest households own most capital their income goes up despite the decline in skilled wages.

The lower income rural households are relatively unaffected by the combined labour and health care shock. This is because, in contrast to the labour supply only shock, unskilled labour wages remain constant. While rural skilled labour wages decline notably as well, again this mostly affects higher income rural households better endowed with skilled labour. For these richer rural households the drop in skilled labour income is compensated by increased capital and land rents.

The only household group that may see a slight decline of income is urban middle class, which will be negatively affected by the decrease of skilled labour wages. However, these changes are rather minimal.

Table 39: Impact of total shock on factor prices (% from Reference Case)

	Wages Unskilled		Wages Skilled		Capital	Land
	Rural	Urban	Rural	Urban		
Hyderabad	0.00%	-0.01%	-0.22%	-0.23%	0.13%	-0.07%
Tam	0.00%	-0.01%	-0.27%	-0.27%	0.16%	-0.09%

Looking at the demand patterns of household and government, almost 70% of government expenditures is directed to public services. On the other hand, households spend almost 50% of their income on business services. Stimulating income of households and government thus leads to an increased demand for both types of services (Table 40) and explains why the sector of business services benefits from a reduced costs of health care.

Table 40: Real government and household consumption (% from Reference Case)

	Primary Agriculture	Food processing	Low-tech industry	High-tech industry	Public Services	Business Services
Hyderabad	-0.017%	0.006%	0.214%	0.181%	2.174%	0.319%
Tam	-0.021%	0.007%	0.256%	0.216%	2.604%	0.381%

Table 41 portrays the impact of the demand and supply changes on equilibrium market prices. There is a general price deflation in the economy, driven by the decline of public sector costs. For some sectors such as business services, prices will go up as a result of increased demand.

Table 41: Impact of total shock on market prices by sector

	Primary Agriculture	Food processing	Low-tech industry	High-tech industry	Public Services	Business Services	GDP Deflator
Hyderabad	-0.011%	-0.007%	0.014%	0.031%	-2.727%	0.019%	-0.354%
Tam	-0.013%	-0.009%	0.017%	0.037%	-3.250%	0.023%	-0.422%

5.2 **Impact on GDP**

Finally, it is possible to compare the macroeconomic impact of both scenarios on GDP, a standard indicator of economic growth. Table 42 shows that the health care costs component has a much larger impact on the economic growth of India. Compared to the reference case, the annual GDP would increase by up to 0.5% with a corresponding decline of the price level. In absolute terms, a 0.5% increase represents about an annually recurring benefit of **28 billion USD**. This estimates in in between the range of ILRI's crude estimates (42 billion for Value of statistical life method and 14 billion for lost GDP method).

Table 42: Impact on real GDP (Absolute and relative difference from Reference Case)

	GDP volume (bln USD)		GDP volume (%)		GDP Deflator	
	Hyderabad	Tam	Hyderabad	Tam	Hyderabad	Tam
Labour Supply Shock	2,999	3,570	0.05%	0.06%	-0.01%	-0.02%
Labour Supply + Health Care Costs	23,513	28,089	0.42%	0.50%	-0.35%	-0.42%

Total GDP effects are in range of 0.5%, which is equivalent to an annually recurring benefit of up to 28 billion USD (for the Tam method) falling in between two crude ILRI estimates of the FBD burden. The implied ratio between the GDP increase per one avoided FBD sickness is about 160 USD per case (note that direct health costs are about 60 USD, showing the indirect economic costs that are born by FBD are 100 USD per case). This means that if FBD burden is expected to amount to as much as one in three, resulting in 500 million cases per year, up to 80 billion USD annually could be gained if investments in food safety are in place.

5.3 Summary of economic impacts

The impacts of the labour and health care shocks were analysed relative to the reference case situation in 2030 assuming no improvement in the FBD burden. It was found that the increase of labour supply (from avoided deaths and sick days) produces a **decline of wages** that creates a **comparative advantage for labour intensive sectors** such as public services, business services (having high share of skilled labour in production costs) and low-tech industry (high share of unskilled labour). This generates **increasing capital and land rent returns** with positive income effects, however, **income inequality** may deepen because *i)* lower income households are less affected by the FBD burden due to their consumption pattern and *ii)* rural low income households are more dependent on wage income than richer households.

Adding health care costs savings to the scenario yields a much stronger response. The increased productivity of public services (which includes health care) reduces costs of this sector, with an important decrease of skilled labour wages and increased governmental income. Inequality effects are also observed, however, in real terms **all household increase their consumption** and hence welfare.

Total **GDP effects** are in range of **0.5%,** which is equivalent to an annually recurring benefit of up to 28 billion USD (for the Tam method) falling in between two crude ILRI estimates of the FBD burden in Chapter 2.

6 Concluding remarks

India, like many low income countries, undergoes a process of transition where rapid economic and population growth coupled with urbanization leads to higher demand for nutritious food and diet diversification towards meat, fruit and vegetables. This inevitable and certainly positive trend in consumption patterns, however, brings along increased risks of food diseases. In light of this prospect, investments in food safety become even more urgent to avoid an increase in food borne disease burden undoing health benefits from the diet transition.

Understanding the economic benefits of an established food safety system in the light of rapid economic transformation is thus important for policy makers to guide them in their investment choices. The empirical evidence on the macro-economic impacts of food safety, however, is rather scarce owing in large part to the lack of country- and food specific data on food disease burden. This study is, to our knowledge, the first assessment of economic impacts of food safety using an economy-wide (CGE) model. Despite certain limitations of the CGE approach, various interesting insights on the way how Indian economy can benefit from an established food safety system were derived. The CGE assessment accounts for both exogenous and endogenous macro-economic changes, providing a valuable complement to existing FBD cost estimates.

From 100 million people today to 170 million people infected in 2030. Recent estimates are that at least one out of 12 people falls ill due to food-related diseases in India. Driven by population and changing consumption patterns in 2030, the number of FBD illnesses are projected to grow by as much as 70% resulting in one out of 9 people falling ill. It is important to note that the expected FBD increase might be still higher given the likely underestimation of the current FBD burden

Food diseases burden on the richer households side. It is not guaranteed that households with higher income are less prone to fall sick by food-borne diseases. On the contrary, due to their preference for more luxurious types of food such as meat, fruit and vegetables, richer households are paradoxically more affected than lower income households. In view of the continuing process of urbanization and GDP growth, every third person in the rich urban household may be affected by FBD by 2030, which is notably more than the average one out of nine.

Therefore, avoiding FBD burden benefits richer households first. Establishing a food safety system that would reduce the FBD burden has thus direct positive impact on higher income urban households. Although an increase in labour supply results in decline of wages, land and capital prices go up which compensates the income gap of the rich households.

Other households benefit indirectly too as real incomes rise and food prices are go down. Not only the richest households gain, but all other households will enjoy economic benefits of the food safety system. This is because a general decline in prices and rise in employment increases real incomes and makes food and services more affordable.

Positive structural changes in the economy in favour of tertiary sector. Because FBD-prone higher income households are better endowed with skilled labour, reduction in FBD related morbidity and mortality makes skilled-labour intensive sectors such as public and private services more competitive. In view of this, it can be concluded that the food safety policy is a policy that creates value added and positive structural change in the economy.

Governmental services such as education and health become more affordable for everyone. The two channels through which a reduced FBD burden affects the economy fuel each other – cheaper skilled labour (labour supply channel) and health care cost savings both make governmental services more accessible, not only health care but also other services such as education and sanitation. An increase in government services may further stimulate economic growth, for example through an increasing skilled labour force, but these long run investment benefits are not captured in the current model.

Positive GDP effects that are comparable to the estimates from the alternative methods. Total GDP effects are in range of 0.5%, which is equivalent to an annually recurring benefit of up to 28 billion USD (for the Tam method) falling in between two crude ILRI estimates of the FBD burden. The implied ratio between the GDP increase per one avoided FBD sickness is about 160 USD per case. Given the possible underestimation of the FBD burden, GDP gains could amount to 80 billion USD, if the illness ratio is one in three instead of one in nine.

It is important to highlight that several key assumptions drive the results of the assessment. Most importantly, these are the economic and population growth assumptions from 2011 till 2030, and the uniform consumption risk ratios across the different demographic groups and in time. We thus do not capture the inverse relation between the level of economic growth and the incidence of foodborne diseases due to improving hygiene with growing income, as pointed out by food safety experts.

It is also important to stress that the quantified economic impacts are probably a lower bound as the current FBD burden and the consumption risk ratios used in the analysis are probably underestimated. Collecting food disease burden data is an ongoing effort and with improved evidence, the precision of this assessment can be higher as well.

Another source of underestimation comes from the applied CGE approach, which solely captures market benefits of increased labour supply and reduced health care costs. However, the benefits of food safety are much broader than that, for instance improved well-being and a reduced child mortality and morbidity of children, with repercussions on children school performance, birth and fertility rates.

Due to difficulties of modelling import preferences and the closeness of Indian economy, the foreign trade benefits could not be explored properly, although bilateral flows are traced in the model. Creating an alternative reference scenario which counts with significant trade opening through substantial changes in the Indian trade policy, and incorporating quality preferences for imported food (if supported by empirical evidence) could provide some additional interesting insights into the role of food safety in Indian economy.

7 References

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8 Annex 1: MAGNET model aggregation

Code	*MAGNET sector*	*FBD*	*GTAP detailed sector description*
pdr	Paddy rice	+	Paddy Rice: rice, husked and unhusked
wht	Wheat	+	Wheat: wheat and meslin
gro	Cereal grains nec	+	Other Grains: maize (corn), barley, rye, oats, other cereals
v_f	Vegetables, fruit, nuts	+	Veg & Fruit: vegetables, fruitvegetables, fruit and nuts, potatoes, cassava, truffles,
osd	Oil seeds		Oil Seeds: oil seeds and oleaginous fruit; soy beans, copra
c_b	Sugar cane, sugar beet		Cane & Beet: sugar cane and sugar beet
ocr	Other crops	+	Other Crops: live plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds, beverage and spice crops, unmanufactured tobacco, cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets; swedes, mangolds, fodder roots, hay, lucerne (alfalfa), clover, sainfoin, forage kale, lupines, vetches and similar forage products, whether or not in the form of pellets, plants and parts of plants used primarily in perfumery, in pharmacy, or for insecticidal, fungicidal or similar purposes, sugar beet seed and seeds of forage plants, other raw vegetable materials
pfb	Plant-based fibers		Plant Fibres: cotton, flax, hemp, sisal and other raw vegetable materials used in textiles
ctl	Cattle,sheep,goats,horses	+	Cattle: cattle, sheep, goats, horses, asses, mules, and hinnies; and semen thereof
oap	Animal products nec	+	Other Animal Products: swine, poultry and other live animals; eggs, in shell (fresh or cooked), natural honey, snails (fresh or preserved) except sea snails; frogs' legs, edible products of animal origin n.e.c., hides, skins and furskins, raw , insect waxes and spermaceti, whether or not refined or coloured
rmk	Raw milk	+	Raw milk
fish	Fishes	+	Fishing: hunting, trapping and game propagation including related service activities, fishing, fish farms; service activities incidental to fishing
wol	Wool, silk-worm cocoons		Wool: wool, silk, and other raw animal materials used in textile
cmt	Ruminant meat	+	Cattle Meat: fresh or chilled meat and edible offal of cattle, sheep, goats, horses, asses, mules, and hinnies. raw fats or grease from any animal or bird.
omt	Meat products nec	+	Other Meat: pig meat and offal. preserves and preparations of meat, meat offal or blood, flours, meals and pellets of meat or inedible meat offal; greaves
vol	Vegetable oils and fats		Vegetable Oils: crude and refined oils of soya-bean, maize (corn),olive, sesame, ground-nut, olive, sunflower-seed, safflower, cotton-seed, rape, colza and canola, mustard, coconut palm, palm kernel, castor, tung jojoba, babassu and linseed, perhaps partly or wholly hydrogenated,inter-esterified, re-esterified or elaidinised. Also margarine and similar preparations, animal or vegetable waxes, fats and oils and their fractions, cotton linters, oil-cake and other solid residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; degras and other residues resulting from the treatment of fatty substances or animal or vegetable waxes.
mil	Dairy products	+	Milk: dairy products
pcr	Processed rice	+	Processed Rice: rice, semi- or wholly milled
sgr	Sugar (without molasse)		Sugar
cvol	Crude vegetable oil		Not directly consumed - processed to vegateble oil for consumption
ofd	Processed food		Other Food: prepared and preserved fish or vegetables, fruit juices and vegetable juices, prepared and preserved fruit and nuts, all cereal flours, groats, meal and pellets of wheat, cereal groats, meal and pellets n.e.c., other cereal grain products (including corn flakes), other vegetable flours and meals, mixes and doughs for the preparation of bakers' wares, starches and starch products; sugars and sugar syrups n.e.c., preparations used in animal feeding, bakery products, cocoa, chocolate and sugar confectionery, macaroni, noodles, couscous and similar farinaceous products, food products n.e.c.
b_t	Beverages and tobacco products		Beverages and Tobacco products
fishp	Fish processing	+	Processed fish products (split from other food products)
oilcake	Oil cake byproduct of cvol		
fishm	Fish meal		
mola	Molasse		
lowind	Other low tech industry		Relatively high labour use industries
highind	Other high tech industry		Relatively low labour use industries
osg	Government services		Other Services (Government): public administration and defense; compulsory social security, education, health and social work, sewage and refuse disposal, sanitation and similar activities, activities of membership organizations n.e.c., extra-territorial organizations and bodies
svcs	Services		

	Code	*MAGNET region description*
Asia	ind	India
	chn	China
	vnm	Vietnam
	SA	Rest of South Asia
	EA	Rest of East Asia
Key partners	EU	EU
	NAFTA	NAFTA
	ME	Middle East
Rest of world	SAM	South and central America
	AFR	Africa
	ROW	Rest of the world