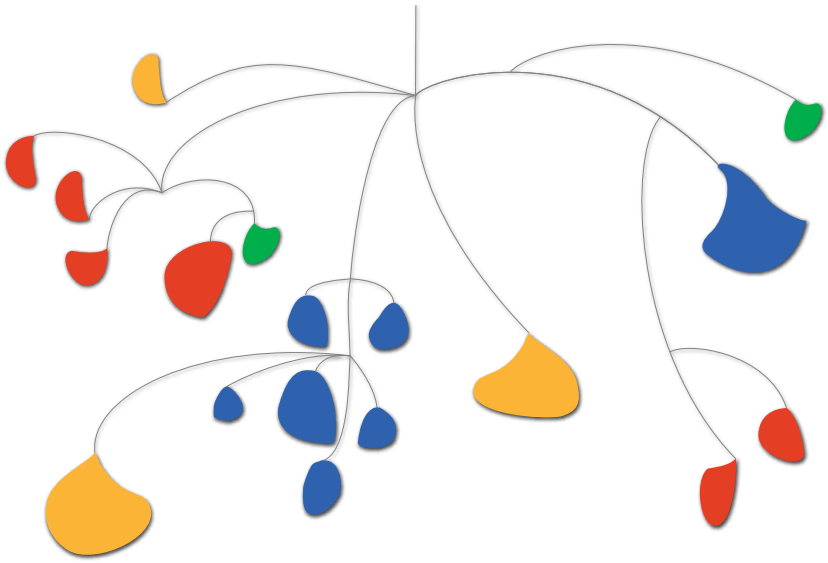
AMIS

Agricultural Market Information System

ENHANCING MARKET TRANSPARENCY



IMPROVING FEED USE ESTIMATIONS: DATA, METHODOLOGIES AND CHALLENGES

An AMIS scoping study
April 2014

This working paper was presented at the 5th Session of the AMIS Global Food Market Information Group, 20-21 May 2014. It is one of the outputs of the IFAD-funded project on "Strengthening knowledge on global food availability and utilization." Under the overall guidance of Ms. Nancy Morgan (FAO Investment Centre) and Mr. Denis Drechsler (AMIS Secretariat), it draws on materials provided by Mr. Pierre Charlebois and other external consultants for the country case studies, as well as inputs from various members of the AMIS Secretariat.

The views expressed in this information product are those of the author(s) and do not necessarily reflect the views or policies of FAO.

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ACRONYMS AND ABBREVIATIONS

AMIS Agricultural Market Information System

DDG Dried distiller's grain

FAO Food and Agriculture Organization of the United Nations

FCR Feed conversion ratio

MBM Meat and bone meal

OECD Organisation for Economic Cooperation and Development

OIE World Organisation for Animal Health

SMP Skim milk powder

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LIST OF DEFINITIONS

Commodity/cereal balance sheet	A tool to monitor market conditions through various elements of supply and demand, by commodity and on national marketing season basis. Supply elements include beginning stocks, production and imports while the demand components include domestic utilization (food, feed, and other uses), exports, and ending stocks.
Feeds	May be broadly classified as concentrates and roughages, depending on their composition. Concentrates are feeds that contain a high density of nutrients, usually low in crude fibre content (less than 18 percent of dry matter) and high in total digestible nutrients. Roughages are feeds with a low density of nutrients, with a crude fibre content over 18 percent of dry matter, including most fresh and dried forages and fodders. Definitions of these feeds and their nutrient contents vary somewhat in the literature; terminology used in this report follows that of FAO (FAO 1983).
Coarse grains	Correspond to the aggregate of maize, barley, oats, sorghum, millet, rye and mixed grains.
Crop protein meals	Are the aggregate of soybean, canola/rapeseed, sunflower, groundnut, cotton seed, copra and palm kernel meal.
Animal origin feeds	Are the sum of fish, meat, bone and feather meal plus skim milk and whey powder
Other crops	Are the sum of roots and tubers (mostly cassava on dry basis) and peas.
By-products	Are the aggregate of molasses, brans, dried beet pulp, corn gluten feed and dried distiller's grains (DDGs
Feed conversion ratio (FCR)	Feed conversion ratio is a measure of an animal's efficiency in converting feed mass into increases of the desired output (e.g. number of eggs by layer hens; liters of milk by dairy cows; mass gained by animals raised for meat production etc.). Specifically, FCR is the mass of the food eaten divided by the output, all over a specified period.

SUMMARY

Feed use accounts for about a third of world consumption of cereals. This share is much larger for coarse grains (56 percent) than for wheat (19 percent) or rice (3.5 percent). Despite its significance, feed utilization is a largely unknown component in supply and demand balances. Within the framework of the Agricultural Market Information System (AMIS), this research project tries to improve our understanding of feed utilization by reviewing feed consumption patterns and methods for estimating feed use.

Case studies were undertaken in six developing countries that are participating in AMIS, namely, China, India, Indonesia, Philippines, Thailand, and Vietnam. All of these countries have seen large increases in their consumption of cereals as feed ingredients with their aggregate feed use of cereals now at around 25 percent of the world total. However, except for maize and rice in the Philippines, there are no official feed use data available for any of the cereals consumed in the targeted countries. Considering their current share of the world market, this lack of any official estimates for cereal feed use constitutes a major weakness in the knowledge of cereal markets in general and in those countries in particular.[1]

In the developed countries, feed use data is typically calculated using the "supply" (or balance sheet) approach. Documenting all the key elements within a balance sheet allows the calculation of feed use as a residual. This method of calculation has many advantages, but assumes that appropriate surveys can be undertaken in order to accurately estimate production, other uses and, most difficult of all, the level of carryover stocks. When the implementation of such surveys is not possible for national authorities, due to logistical or other contraints, then the "demand" approach provides an alternative solution: calculating how much feed animals actually require. As illustrated in this report, the success of this approach is largely conditioned on the availability of reliable information about the livestock sector, including the type of animal and animal numbers. Furthermore, it would be necessary to prepare customised surveys to collect some of the more problematic variables, such as the extent of on-farm feeding and feed conversion ratios.

The report identifies the "pros and cons" of the various methodologies, discusses the data requirements for estimating feed use in the context of cereal balance sheets and reviews some of the options for a better estimation of cereal feed use.

[1] Commodity balances show balances of food and agricultural commodities in a standardized form on an annual basis which includes data on production, supply (production plus beginning stocks and imports) and distribution (food/feed/industrial use/exports) of specific commodities.

I. Introduction

About one third of all cereals (coarse grains, wheat and rice) consumed globally are used for animal feed. Growing incomes can be expected to further increase this share relative to other uses, such as food, especially considering that the income elasticity of demand of animal products is much higher than for cereal food products.[2]

Within the framework of the G-20 Agricultural Market Information System (AMIS), the objective of this report is to assess current patterns of feed consumption and to identify challenges that impede a better estimation of this element in cereal balance sheets, including weaknesses in national data systems and overall knowledge/information gaps. To this end, the report reviews methodological options for estimating feed use and highlights challenges for developing countries, drawing on lessons derived from six Asian countries that are members of AMIS: China, India, Indonesia, Philippines, Thailand, and Vietnam, and benchmarking these lessons with methodological approaches for feed-use estimation applied in developed countries. Despite the focus on Asia, findings of the case studies may also be relevant for developing countries in other regions, many of which have experienced rapid economic growth over the last 20 years, resulting in higher incomes and an increased consumption of animal products.

Apart from capture fisheries, the production of animal products is the result of human activities involving some sort of feeding practices. The continued rapid growth in feed demand will have important implications for resource use as well as for food consumption. This implies that good statistics on the amount of cereals consumed as feed will only become more important in the future. Unfortunately, however, feed use has been, even in developed countries, one of the elements of the cereal balance sheet that has received less attention. This study tries to address this gap.

II. The importance of cereals in the world feed market

Cereals have been, and will remain, the most important ingredient in animal feed, as can be seen in Figures 1, 2 and 3, which are based on data and projections of the *OECD-FAO Agricultural Outlook*.[3] Among cereals, coarse grains are by far the most important ingredient of feed. The share of coarse grains exceeded half of the concentrate feed market at the beginning of the century but has declined slightly since 2010-2012 (Figure 1). Only slow growth is projected over the next decade as a large

[2] A one-percent increase in income results in a higher consumption of animal products than cereal food products.

[3] The *OECD-FAO Agricultural Outlook 2013-2022*, combined with the author's forecast for meat and bone meal, by-products and other crops. The *Agricultural Outlook* is a collaborative effort of the Organisation for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization of the United Nations (FAO). It brings together the commodity, policy and country expertise of both organizations as well as inputs from collaborating member countries to provide an annual assessment of prospects for the coming decade of national, regional and global agricultural commodity markets.

increase in demand for higher protein feeds, such as soybean meal (see Figure 2), combined with strong demand for maize from the ethanol industry, puts upward pressure on the relative price of maize, the most important coarse grain used as feed. Meanwhile, the combined share of wheat and rice as feed ingredients has fallen and stabilized at around 10 percent. Based on the latest OECD-FAO projections, the share of coarse grains for feed is expected to grow again after the ethanol mandate expires in the United States in 2015, a policy which has heavily impacted the global use and prices of cereals, particularly maize, over the past decade.

Figure 1: Share of cereals in total concentrate feeds consumed at the world level

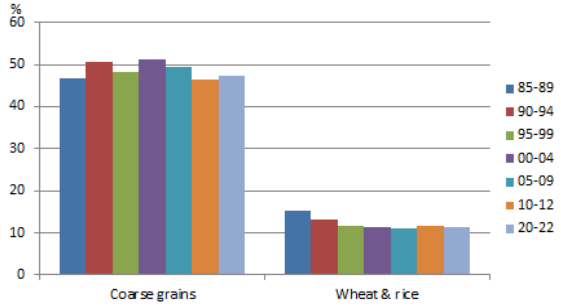


Figure 2 shows the rapid growth in high crop protein meals compared to the declining share of animal origin feeds[4] (meat and bone meal, fishmeal, skim milk and whey powder) as a component of total feed use. The use of animal proteins is expected to continue falling, but at a slower pace. The growth in the share of high crop protein meals for feed, soybean meal, etc, has been the strongest in terms of relative size. The growth has been catalyzed by structural changes in animal industries, in particular intensification and integration, and improved feed rations in many countries of the world, including the six Asian countries reviewed in this report. An illustration of this growth is the rapid expansion of large scale poultry and pork industries in China and the consequential escalation in demand for protein meals as input into feed rations. More protein requirements in animal feed have pushed China into the position of the largest importer of soybeans in the world, estimated to account for nearly 60 percent of global totals in 2014.

Figure 2: Share of high protein feeds in total concentrate feeds consumed globally

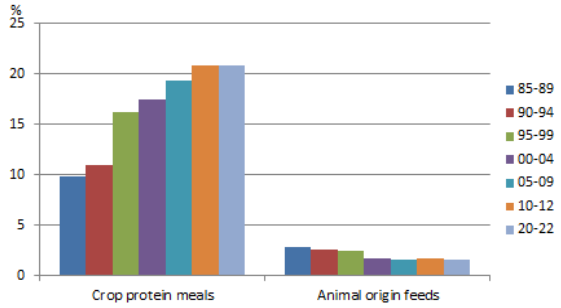
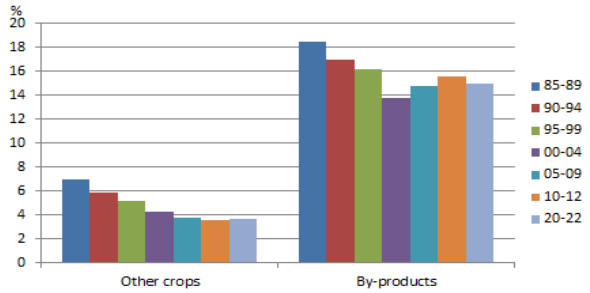


Figure 3 reveals that the share of other crops (e.g. roots, tubers, legumes) as feed inputs has fallen over the past three decades and is expected to remain stable over the next decade, somewhat similar to developments observed for by-products. By-products, such as bran, molasses, dried beet pulp and corn gluten feed, are frequently a residue of food items that are characterized by relatively low income elasticity of

[4] Declining use of animal protein meals is linked to international limitations on the use of meat and bone meal as animal feed in the aftermath of the BSE crisis (mad cow disease).

demand (e.g. bread, pasta, tortilla etc.). With consumption of these food items remaining relatively stable, the share of by-products in global feed utilization has declined compared to cereals and protein meal. The reversal of the trend from 2005 onward can be explained with the surge of cereal-based ethanol production, which has resulted in a growing production of dried distillers' grains (DDGs). With the end of the current US ethanol mandate in 2015, cereal-based ethanol production and DDGs availabilities are not expected to grow as rapidly. This change may likely generate a new reversal in the share of by-products used as feed.

Figure 3: Share of other feeds in total concentrate feeds consumed at the world level



Over the medium term, the distribution of cereals between food, feed and fuel is expected to remain relatively stable with only a small increase in feed use at the expense of fuel. In the absence of policy shifts, the allocation of cereal use would be determined by the relative purchasing power of consumers as well as the price of animal products and fuel. Especially shifts in energy prices have the potential to influence prices for cereals, forcing a rationing between other cereal-use categories, in particular between animal feed and food consumption. If, on the contrary, energy prices remain relatively stable, consumption patterns of the growing middle class consumers in many developing countries will likely determine cereal prices through their increased consumption of animal products.

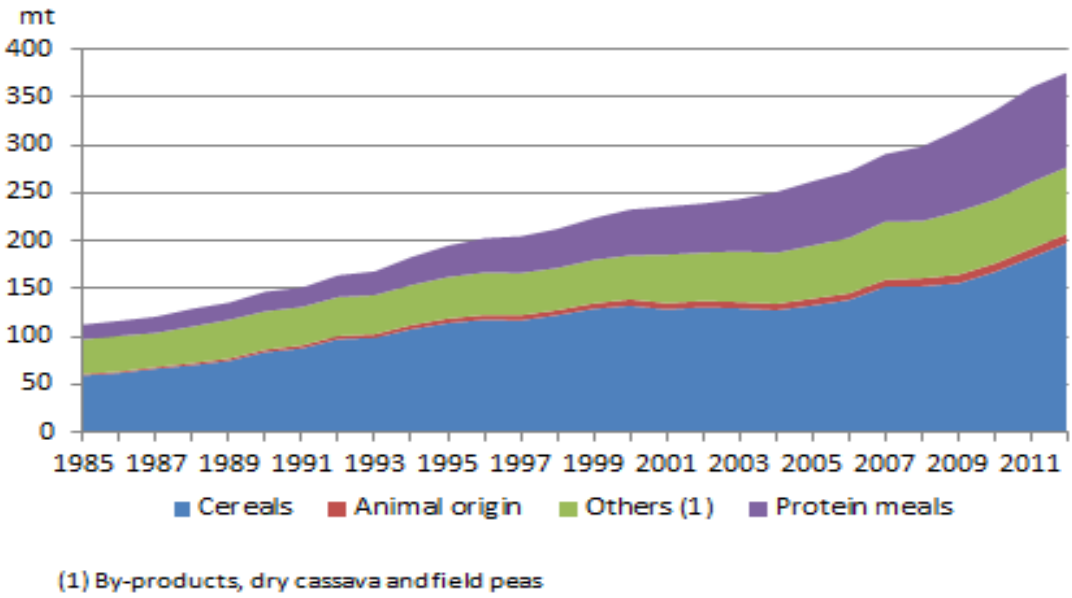
III. Feed and animal product markets: The case of six countries in Asia

The six countries covered in this report (China, India, Indonesia, Philippines, Thailand and Vietnam) represent about 25 percent of global cereal use for feed. China alone is now the largest consumer of feed ingredients in the world, absorbing one fifth of global totals. Rising incomes in these countries have led to a rapid growth in the consumption of animal-based products, which has mostly been met by local production. These developments have led to a very rapid increase in the consumption of concentrate feeds, progressively accelerated by a shift from smallholding production to larger-scale commercial operations. While annual feed consumption stood at approximately 114 million tonnes in the mid-1980s, this number had increased to about 358 million tonnes in 2009-2011, of which 183 million tonnes were cereals. Cereals are, therefore, estimated to account for 51 percent of total feed use, which is very similar to the share in the United States of 53 percent.

Animal production systems in the case-study countries have also been subject to major shifts in the composition of feed rations. With the exception of India, which is a major protein meal producer, the share of low protein feeds (a category which includes cereals) ranged around 85 percent of total feed use in the mid-1980s. In

Vietnam, for example, this share was even reported at 98 percent. As a result of the growing intensification of livestock industries, this ratio has gradually decreased and now varies between 61 and 76 percent. As indicated in Figure 4, the feed ingredient that registered the largest gain in the six countries is protein meal, mainly soybean meal, which increased from 14 percent in 1985 to 27 percent in 2010.

Figure 4: Concentrate feeds consumed in six Asian countries



The changing composition of feed rations and a higher incorporation of protein, such as soybean meal, has improved the overall feed conversion ratios (FCR) of these countries, reflecting the animals' improved efficiency in converting feed mass into the desired output, such as milk, eggs, meat, etc. Improvements have been particularly strong in farms using concentrate feeds, which have now attained the same – or very similar – FCRs as developed countries. Most of the improvement occurred between 1992 and 2002, as illustrated in Table 1.[5] Since backyard farms use much less concentrate feeds, the weighted average FCR of concentrate feeds is smaller than for specialized and commercial farms.

[5] The numbers presented are based on a literature review and also draw from the individual case study reports. To have a complete historical series, many assumptions, extrapolations, interpolations and other statistical techniques were employed. For that reason, the numbers merely show the general evolution of product-specific FCRs. In the context of developing countries, it is also necessary to consider the percentage of backyard farms that are feeding their animals with roughages and waste while making assumptions about the use of concentrate feeds.

Table 1: Estimated feed conversion ratios (FCR)[6], percentage of backyard farms, and weighted average FCR of concentrates

Product	Year	(FCR in kg, share %)	China	Indonesia	India	Philippines	Thailand	Vietnam
Pork	1992	Commercial farms FCR	4.32	4.12	3.75	4.06	3.8	4.69
		Share of backyard farms (%)	74	81	88	80	61	80
		Weighted average of concentrate feeds	1.83	2.79	0.47	2.76	2.88	3.19
	2002	Commercial farms FCR	3.77	3.75	3.75	3.75	3.75	4.18
		Share of backyard farms (%)	68	79	84	77	17	80
		Weighted average of concentrate feeds	1.4	2.57	0.61	2.6	3.5	2.84
	2012	Commercial farms FCR	3.75	3.75	3.75	3.78	3.75	3.75
		Share of backyard farms (%)	60	75	73	65	2	50
		Weighted average of concentrate feeds	1.95	2.63	0.99	2.8	3.72	3
Poultry	1992	Commercial farms FCR	2.07	1.85	1.8	1.95	1.82	2.25
		Share of backyard farms (%)	49	35	0	60	38	80
		Weighted average of concentrate feeds	1.28	1.69	1.8	1.37	1.48	1.35
	2002	Commercial farms FCR	1.81	1.85	1.8	1.8	1.8	2
		Share of backyard farms (%)	45	22	0	60	22	80
		Weighted average of concentrate feeds	1.06	1.75	1.8	1.26	1.6	1.2
	2012	Commercial farms FCR	1.8	1.8	1.8	1.82	1.8	1.8
		Share of backyard farms (%)	39	16	0	47	18	63
		Weighted average of concentrate feeds	1.24	1.77	1.8	1.39	1.64	1.24
Eggs	1992	Commercial farms FCR	2.53	2.42	2.2	2.38	2.23	2.75
		Share of backyard farms (%)	49		0	60		
		Weighted average of concentrate feeds	1.56		2.2	1.67		
	2002	Commercial farms FCR	2.21	2.2	2.2	2.2	2.2	2.45
		Share of backyard farms (%)	45		0	60		
		Weighted average of concentrate feeds	1.3		2.2	1.54		
	2012	Commercial farms FCR	2.2	2.2	2.2	2.22	2.2	2.2
		Share of backyard farms (%)	39		0	47		
		Weighted average of concentrate feeds	1.51		2.2	1.7		

Source: Calculations made by the author.

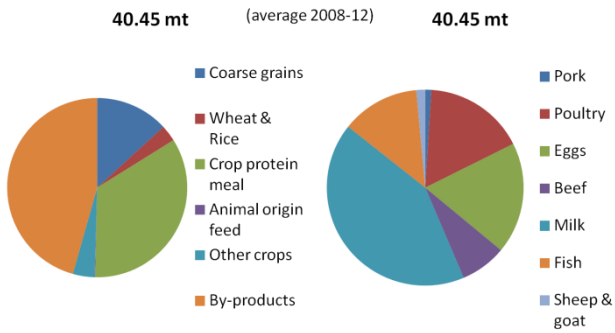
[6] Amount of feed needed per unit of product on a live weight basis.

The FCRs presented above are derived from the use of concentrate feeds, not including all the dry matter consumed. As illustrated in the table, there are two contradictory factors influencing national FCRs. First, the FCR of specialized and commercial farms are improving over time, i.e. they are falling. However, the share of production originating from backyard farming is falling, leading to higher consumption of concentrate feeds. For the country as a whole, the weighted average could be falling or increasing, depending on the interaction between those two factors. In the case of pork, between 1992 and 2002, the effect of the improvement in FCR of specialized and commercial farms was stronger than the impact of the reduction in the share of backyard farming.

With a relatively stable FCR of specialized and commercial farms between 2002 and 2012, and a continued reduction in the share of backyard production, the overall FCRs of pork and poultry systems using concentrate feed has increased. This implies that while improvements in FCRs are still possible, changes in the farming structure will have less impact on feeding practices than in the past. If the share of backyard farming continues to decline in the six countries, they will be requiring more concentrate feeds per unit of non-ruminant production since improvement in FCRs will not be offsetting the growth in consumption caused by the changing farm structure. This could be an important source of feed demand in the future.

As can be expected, aggregate numbers as presented in Figure 4 mask significant differences between the feed markets of the six countries.[7] Figures 5-9 review the availability and use of feeds in case study countries using 2008-2012 averages. These differences are particularly evident in India (Figure 5), where the share of cereals in total concentrate feed is much smaller than in China and the other ASEAN countries because pigmeat and beef consumption is very limited for cultural reasons. Demand from the forage-linked dairy sector, on the other hand, is very large. For the other countries, with the exception of Indonesia as a Muslim country, the pork sector drives feed demand, with cereals and protein meal accounting for the largest share of the feed ingredients. Thailand, with its large poultry exporting sector is also a large producer of cassava. This availability is channeled into pig and ruminant production, thus explaining its heavy use of by-products and cassava in feed, which can also be observed in Vietnam.

Figure 5: Type of feeds and consumption by species in India



[7] Indonesia is omitted because of the apparent inconsistency in the estimation of maize (see page 20).

By contrast, all six countries are similar in that the aquaculture sector has a large impact on the total consumption of feed ingredients, as illustrated in Figures 5 to 9. The amount of feed consumed by each species, expressed in million tonnes (mt), is based on the FCRs presented in Table 1, and for that reason should be considered as a rough estimate.

Figure 6: Type of feeds and consumption by species in China

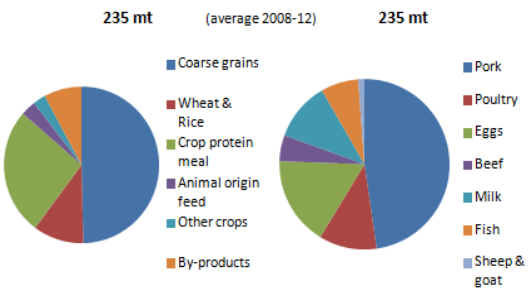


Figure 7: Type of feeds and consumption by species in the Philippines

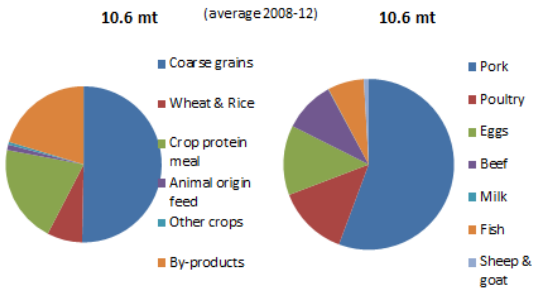


Figure 8: Type of feeds and consumption by species in Thailand

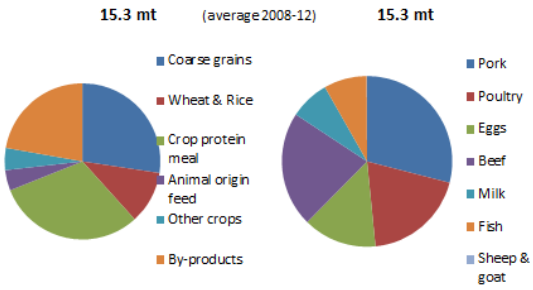
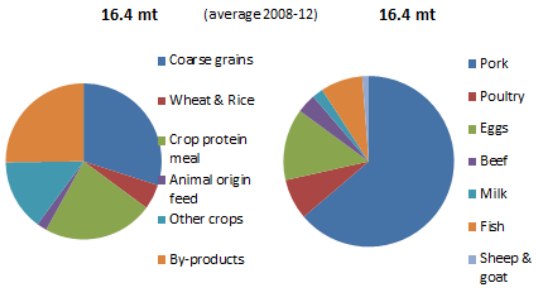


Figure 9: Type of feeds and consumption by species in Vietnam



IV. Estimating feed use: Options

The previous sections highlighted the growing importance of feed as a component of the cereal balance sheet and reviewed some of the feed-related developments in selected Asian countries. Recognizing the importance of estimating feed use is not new of course, as evidenced by efforts during and right after the Second World War when countries tried to understand feed requirements in the context of war-torn Europe (Baker, 1988). However, the current and growing demand for animal products and their underlining feed requirements, particularly in developing countries, reinforces the need for a thorough review of the methodologies available to estimate these requirements.

Despite the recognized importance of cereal consumption for feed, there is a clear lack of a strong understanding on how to derive feed use estimates. This, combined with data deficiencies, poses a serious methodological gap for estimating uses for cereals, which are the source of most calories globally consumed for food. This section reviews data and methodologies currently available for estimating feed use. Three methodologies have been proposed.

The survey approach

One method to estimate feed use is through feed surveys. If these surveys are limited to companies that produce compound feed, this can be achieved at reasonable cost. However, if the surveys are supposed to provide feed estimates for the inclusion in cereal balance sheets, they should also target the consumers of cereals for feed, which is very costly to achieve. Additional challenges include the need to disentangle the annual change of the cereal mix in feed rations of the various types of compound feed[8], and to estimate feed that is produced and consumed directly on the farm. In fact, livestock and fish farmers can use any of the following three feeding practices: 1) buying complete compound feed, 2) procuring prepared formula that they mix with their own feeds; or, 3) relying entirely on their own feed or purchases from neighbors.

In developed countries, the need for on-farm feed surveys has long been recognized, but it is rarely implemented given the excessive costs. Recently in the US, in the context of the growing intensification of the livestock industry, more practical and cost-effective methods for estimating feed have been proposed. For example, useful data series could be established using a sample of larger operations from each of the major livestock species, which would allow a better understanding of the use of feed on the farm as well as understanding of the changing structure of farms over time (Westcott and Norton, 2012).

Among the most difficult information to discover or to impute is the amount of concentrate/supplemental feed to ruminants and non-ruminants in backyard and small-scale livestock operations. The amount used in both of these production systems is affected by annual market conditions, and it would be difficult and expensive to design survey methods to adequately capture this information. In developed countries, this is less problematic because of the dominance of more intensive production systems, such as feedlotting for ruminants, and the relatively small share of small-scale production systems.

Supply based estimation: The balance sheet approach

Another methodology is the "supply" or "balance sheet" approach, which is used by the US Department of Agriculture and Statistics Canada, for example. This methodology essentially consists in estimating feed use as the unknown variable in a supply and demand balance of a given commodity that is otherwise complete. Specifically, national statistical agencies, through surveys, derive statistically valid cereal production figures and beginning stocks. Imports, the other element of supply, are usually available from customs authorities. All elements of supply are, therefore, based on survey or actual data derived from official sources.

[8] The composition of compound feed shifts depending on the prices of the various feed ingredients which are blended in the feed mill according to the specifications outlined by the animal nutritionist. If the ration is not apportioned correctly, it will affect the profitability of production through lower animal production and higher costs.

On the utilization side, all other elements are calculated, with the exception of export figures, which are available from the Customs Department. These categories include food, feed, seed use, industrial use and waste (see Figure 10). Seed use is typically based on area planted obtained from the production surveys. Food and industrial use (excluding ethanol) are based on surveys of the industrial sectors including, for example, bakery/pastry, grain sweeteners and beer. The amount of cereals used for ethanol production is obtained from ethanol plant capacity information. While this might have been acceptable when ethanol production was small, the growth in DDG feed use might justify an annual survey of the amount of cereal used by ethanol producers as well as the production and stock of DDG.

Figure 10: A Commodity Balance Sheet

	2011/12	2012/13 Est.	2013/14 Proj.
Area Planted			
Area Harvested			
Yield per Harvested Acre			
Beginning Stocks			
Production			
Imports			
Supply, Total			
Food			
Seed			
Feed and Residual			
Domestic, Total			
Exports			
Use, Total			
Ending Stocks			
Avg. Farm Price ($/kg)			

In the supply approach, feed, which is usually called "feed and residual" or "feed and waste", is calculated as the residual, i.e. the quantity remaining after all other elements of the balance sheet have been estimated. The shortcoming of this approach is that errors associated with any or all the elements of the balance sheet get reflected in the feed data. Also, and clearly problematic, this approach does not guarantee consistency between the amount fed and animal feed requirements.

The demand approach or estimating animal feed requirements

Calculating feed use through the estimation of animal requirements (i.e. the "demand" approach) has been proposed as a substitute to the supply approach typically adopted through the use of cereal balance sheets. In developed countries, the demand approach methodology, with the exception of the EU (see Box 1), is typically not used directly to calculate feed use but rather within the context of the supply approach to verify the estimated feed numbers against an evaluation of animal requirements.

Like the other two approaches, there are challenges associated to the demand approach, as this methodology requires good information on the following elements:

- Animal production (including the aquaculture species) and/or animal inventories by sex and age structure
- Feed conversion ratios
- Share of production undertaken in intensive, semi-intensive and extensive operation, and the share of concentrate feeds used (which will vary by year) in each type of operation.
- The use of all other possible concentrate feeds that can replace cereal in the feed formulation process.

- An estimate on how much fodder feeds (hay, pasture and cereal silage) are used by ruminants.

The demand approach requires national agencies to undertake livestock data collection activities, such as animal inventory surveys as well as technical surveys, as well as drawing on research to reveal the changing structure of the livestock sector, along with specific technical indicators such as feed conversion ratios. It is therefore particularly problematic in many developing countries as the number of animals, for example, is usually a "guess-estimate". Similarly, the composition of herds/flocks, the structure of the industry, and the degree of sector intensification is equally unknown.

Box 1: Estimating feed use in the EU

The European Commission is responsible for the management of agricultural markets in the European Union in order to ensure a stable supply of food. In order to elaborate supply and demand balance sheets for cereals, oilseeds and protein crops knowledge of the consumption of cereals and other crops is required. Since 2009, the animal feed use of the European Union is estimated with a quantitative model – FeedMod - developed at the request of the European, Commission especially for this purpose. The model was updated in 2014 to include Croatia, integrate new raw materials and improve the on-farm feed estimates.

FeedMod is a computer based model which is able to estimate the tonnage of raw materials used to produce industrial compound feed on one hand, and on-farm feed on the other hand. FeedMod provides outputs for the Union which can be fractioned at Member States level, for the main livestock groups (pigs, dairy cows, beef cattle, poultry meat and layers) on a quarterly basis.

First, the tonnage of raw materials used to manufacture industrial compound feed is calculated by FeedMod on the basis of a linear optimization process called 'least-cost formulation'. This method reflects the current practices of European feed manufacturers. The optimization process takes into account the nutritional compositions of raw materials, feed rations (as a function of animal group and physiological state), incorporation rates of raw materials and delivery prices of the raw materials. The model is frequently updated with statistical data at Member State level on animal numbers, animal production (meat, eggs, milk, etc.), industrial compound feed production and usable crop production.

Second, concerning the on-farm consumption, the model distinguishes between on-farm compound feed and roughage. A certain number of features are different for industrial compound feed and on-farm compound feed - e.g. the list of raw material (produced on-farm or available locally) is less diverse, the influence of raw material quotation is reduced and the feed formulation is more stable. Consequently, an optimisation based on minimizing the cost of rations is not relevant to estimate on-farm compound feed. On-farm compound feed is considered as an independent variable taking into account amongst others the usable production of cereals. It is estimated for all categories of animals by Member state. In the case of cattle, the energy supplied by green fodder is also estimated as an independent variable based on the actual production of grassland (remote sensing based biomass indicators are used for that scope) and silage maize. For each animal category, the total volume estimated to be consumed on the farm is adjusted in line with the theoretical need of animals.

In addition to the estimation of feed use, the model allows to follow the evolution of the feed cost based on the prices of various raw materials.

Source: The European Commission

V. Considerations when reviewing the options for estimating feed use

Determining the residual in the supply approach

If a country decides to apply the supply approach, the choice of the residual variable is important. Three criteria have to be considered: the variable's relative size, its anticipated variability over time and the cost of obtaining the information through surveys.

Based on these criteria, **cereal stocks**, for example, is a problematic element to be used as a residual variable because it is small relative to production, food and feed use. Consequently, any errors in the compilation of the data of the larger variables would result in large errors (in percentage terms) in a small residual variable like stocks.

The same holds true for **cereals used for fuel production**. The growing importance of cereal-based ethanol production suggests that the current method of calculation using ethanol plant capacity should be replaced by a real evaluation of the amount of cereals used by these plants through surveys.

Import and export data are typically the most reliable because they are available from national customs authorities. Consequently, assuming that stocks can be obtained from unbiased surveys, the residual variable has to be production, food use or feed use.

For the majority of coarse grains, **production and feed use** are the most significant variables in terms of quantity, which make them the logical candidates to be calculated residually.

The calculation of c**ereal production** has two elements, which are critical for market analysis: area harvested and yield. Yield estimates are important for understanding crop productivity, and area harvested is important to understand resource shifts between crops. If production is calculated residually, these two

Box 2: Models for estimating feed use: Who is doing what?

Numerous organizations have tried to develop models to estimate national feed use based on livestock feeding requirements, including the US Department of Agriculture whose activities on estimating feeding rates started in the 1940s. However; accurate estimates on national feed use need reliable data on animal numbers, rates of weight gain by type/age of animals, feed conversion factors by different types of operations/animals, as well as information on regional and seasonal feeding practices.

Recently, the FAO, with the objective of enhancing Food Balance Sheets (FBS) in FAOSTAT has adopted a new model for the estimation of total feed based on animal nutritional requirements. The current model is based on key factors of feed demand including herd size, the estimated proportion of animals under intensive livestock farming, the herd composition in terms of animal type, the animal's live weight, approximated by extrapolating carcass weight, their approximated live weight gain, and milk and wool production.

Key research gaps, such as documenting the changing structure of livestock systems in developing countries and better understanding how to allocate aggregate feed requirements among individual feeds, are recognized as key challenges and are being addressed through dialogue with developing countries.

variables would not be available. Area harvested is also useful in determining another small element of demand, i.e. seed use. For all of these reasons, production data are usually derived using good quality surveys and/or remote sensing technologies.

The issue of estimating food versus feed

The determination of the residual, either food or feed, has to be assessed in the context of the costs of surveying food versus feed companies regarding the use of individual cereals in production.

- If all feed ingredients were processed by compound feed companies, designing surveys to determine feed use could be an option. Often, however, this would be difficult in developing countries since a large part of feed utilization is on-farm, using local feed.
- Assuming that the cost is not prohibitive, a survey-based approach to estimate food demand would have the advantage of allowing the calculation of feed residually in the balance sheet.
- Considering the frequency of substituting different types of cereals and other by-products in the feed mix, calculating feed residually also has the advantage of capturing significant feed-use changes based on changing prices, etc. However, the quality of the residually-derived feed estimate depends on the quality of the compilation undertaken for the other variables of the balance sheet.
- The disadvantage of the supply approach is that it does not guarantee consistency between animal requirements and feed consumed. Consequently, an estimation of animal feed requirements should also be done even when the supply approach is retained to calculate feed use.

Ensuring consistency between feed use and feed requirements

Ensuring consistency between balance sheet estimates of cereal feed use and feed requirements[9] is a useful step to derive better estimates of feed use. This is currently the method used by the EU to derive aggregate feed use with the task being less complicated than for developing countries because non-ruminants production in EU Member States typically occurs in intensive operations and is thus less reliant on on-farm feeding practices. Below are some of the challenges inherent in deriving cereal feed estimates from animal feed requirements:

- Surveys on livestock numbers need to provide representative data on the structure of herds/flocks which include sex and age structure (required for the proper calculation of requirements). In addition, countries need to be able to monitor and quantify farm structures and diversified feeding practices, which are often evolving rapidly in a developing country context.

[9] A more detailed review of all the assumptions needed with the demand approach is presented in a forthcoming paper by Hoffmeister and Dalheimer.

- If data on animal inventory are not reliable, statistical agencies could calculate feed requirements on the basis of animal product production, but that would bring inter-annual bias because pork, beef and some type of fish are fed over longer periods, thus resulting in an under-estimation of feed requirements in some years and over-estimation in others.
- The composition of feed use, both on-farm and in the feed mill, is subject to on-going economic decisions made by animal product producers and compound feed companies. The use of waste and fodder feeds is based on daily economic assessments undertaken by farmers taking into account the price of concentrate feeds, the impact on the quality of the output, and the extra time and labor required. This is particularly true for ruminant production since farmers can always make greater use of fodder feeds when market conditions and prices of substitute feed ingredients change. Consequently, assuming a fixed percentage of these feeds in the annual rations would not be realistic because the amount used varies according to market conditions that change frequently.
- Calculating national level feed requirements necessitates additional data on the aquaculture sector which is important in many developing countries, including those covered in this report. As with livestock, there is a multitude of feeding intensities depending on the species and the specific national context. The numbers presented in Annex 1 provide some examples of feed rations that can generate an optimum FCR for different aquaculture species. But again, similar to livestock, depending on prices of feed and fish, farmers can change their level of feeding intensity for some species, making greater use of natural nutrients present in the ponds.
- Consequently, FCRs for different systems can be an underestimation because many farmers have not reached the optimum level, or they can be an overestimation if farmers use less intensive feeding practices and thus less concentrate feeds. An assumption has to be made about the average FCR of each species for each country, and these FCR can fluctuate.

Table 2: Pros and cons of the different methodologies to estimate feed use

Methodologies	Advantages	Disadvantages
Feed surveys	1. Firm surveys on compound feed production are useful and less costly than on-farm surveys. 2. For on-farm surveys, it is less expensive and more reliable when introduced in intensive feeding systems. Options could include selected surveys targeting "typical" livestock holdings.	1. Extremely expensive when production systems are dispersed and characterized by variable feeding systems.
Supply approach	1. The availability of reliable surveys (or methods of imputation) of food use and stock	1. Surveys to determine food consumption and stocks can be expensive and unreliable

	allows the use of the supply approach to calculate feed use residually in the balance sheet. 2. The supply approach captures economic decision making by economic agents. 3. This approach requires the least amount of information because feed of a particular cereal can be calculated residually without requiring information on animal requirements and use of competing feeds.	depending on the respondents' willingness to provide timely and accurate responses. 2. The final feed number may not be consistent with animal feed requirements.
Demand approach	1. If well constructed and the different model parameters are available in good quality, the demand approach can generate overall feed figures that are consistent with animal feed requirements. 2. The demand approach allows the calculation of stocks residually when surveys are not possible.	1. The amount of data required to run these models is extensive and often not available, even in many developed countries. 2. The analysis is underpinned by many assumptions and strong technical capacity is required, which is often lacking in developing countries. 3. Each cereal cannot be evaluated alone. Overall feed requirements are calculated based on selected livestock parameters, and it is difficult to derive the feed use of each individual feed ingredient to include in the cereal balance sheet. 4. Within the balance sheet, another variable has to be selected to be calculated residually. Because of the inherent errors in the calculation of all the elements of the balance sheet, the residual variable could carry a large percentage error. This is problematic for stocks, which is a smaller component of the sheet, or food use, which is typically less volatile than other elements.

Once the data is available to estimate feed use: What then?

When the total amount of livestock/aquaculture feed requirements is estimated, the cereal composition needs to be determined, i.e. disaggregating and redistributing total cereal feed requirements among maize, barley, oats, sorghum, wheat and rice.

Compound feed producers typically adopt the use of the least cost formula[10] which allows them to produce compound feed using different rations of feed ingredients in order to minimize input costs. While commonly undertaken by companies and by the EU Commission, the least cost formula requires very good price information for every product over the course of the year.

Assessing the results

Considering the numerous assumptions and data requirements to estimate feed use, criteria have to be identified to verify the plausibility of the numbers calculated.

- The easiest indicator to review using the supply approach is stock levels in the first year; feed numbers derived by the demand approach need to avoid any negative ending stocks calculated residually in any of the subsequent years. If the stock level in the first year generates a very large "stock to use" ratio, this would be a sign that there is a data problem in one or more of the elements of the balance sheet, including feed use.
- If there are significant inconsistencies between feed numbers generated through the supply and demand approach respectively, key assumptions in the demand approach need to be reviewed. These include: 1) the degree to which the commercial and specialized farmers of non-ruminants have reached the optimum FCR; 2) a re-assessment of the share of production in intensive versus backyard farms; 3) varying assumptions of the amount of concentrate feeds used in non-ruminant and ruminant backyard production; 4) revising the aquaculture FCR either because it is believed that farmers have not reached the optimum FCR (if an increase in the consumption of feed by aquaculture is needed) or that they are using lower intensity feeding practices (if a decline is needed).

VI. Developing countries: Challenges in implementing the various methodologies for estimating feed use of cereals

As illustrated in the discussion above, properly estimating the amount of cereal used for feed is a challenging task. When it is undertaken through the supply approach, surveys are necessary to derive the elements of the balance sheet such as production, stocks, food use and amount used by the ethanol sector. However, also the demand approach requires national agencies to engage in extensive data collection activities, for example to establish animal inventories and capture the changing structure of the livestock sector. For developing countries, at least five significant challenges complicate the estimation of feed use:

1. Weak communication infrastructure and limited institutional linkages between the agencies responsible for collecting the data, as well as between these

[10] The least cost formula is done with sophisticated linear programming method to minimize the cost while respecting some nutrients criteria.

agencies and the economic actors, especially farmers. In addition, the excessive cost of producing these surveys is difficult in an environment of limited financial capacity.

2. The generally lower level of education of the farming community compared to developed countries. This translates into logistical challenges and increases the cost of doing surveys. It can also reduce the quality of the results obtained.
3. The larger amount of cereals consumed on the farm (either as feed or food) compared to developed countries. Considering that farmers represent a much larger share of the total population in developing countries, this challenge needs to be addressed through regular technical surveys or be properly evaluated using other methods.
4. The flexibility of operations and households to shift feeding practices depending on market conditions. Feeding practices of some non-ruminant and fish production system under backyard feeding systems are very flexible as regards their requirements for concentrate feeds, with usage varying depending on market conditions. In that context, assuming a fixed amount of concentrate feed per animal or per unit of production every year will lead to errors in overall feed estimation.
5. Adoption by developing countries of the supply approach can only be effective if the country's statistical system is able to undertake statistically sound and cost effective surveys of stocks and food use.

The six case studies covered in this report confirm the considerable challenges to estimate feed use in developing countries (for more country specific details, see Annex 3). In all of the countries the animal and feed sectors are in a process of rapid evolution, with many of them experiencing environmental challenges, both on the livestock side in terms of externalities linked to intensifying livestock systems and on the feed availability side with access to arable land and water potentially restricting output.

With the exception of the Philippines, where the Bureau of Agricultural Statistics (BAS) of the Department of Agriculture produces a very comprehensive database of agricultural statistics, none of the countries investigated in this report generates official feed use estimates. In the Philippines, data on production originating from backyard farms is available since 1994, and complete balance sheets, using survey data for both stocks and production, are available since 1990 at least for maize and rice. The country is thus able to use the supply approach to calculate feed use of maize and rice as the residual.

In India, and also in Thailand, an evaluation of the potential feed supply is reportedly undertaken for the country as a whole and by sub-region. But the estimates don't reveal the exact amount of cereals fed because each of the feed products analyzed could be consumed as food, stored or exported.

In China, the National Center for Grain and Oil Market compiles balance sheets of major cereals and oilseeds but that information is supplied on a commercial basis[11]. That Center uses the official production data from the National Statistical Bureau and trade data from customs authorities. Based on linkage with the livestock industry, the Centre is able to impute the rest of the balance sheet including feed use. However, these estimates are often distorted from lack of sufficient human and financial resources to carry out statistical sampling.

In Indonesia, measuring feed use appears particularly problematic because production data, at least for maize, is a subject of considerable controversy. The Central Board Statistics (BPS) of Indonesia reported that maize production in 2012 was 18.96 million tonnes while USDA reported only 8.9 million tonnes, a difference of 10 million tonnes. This difference is not due to a simple annual estimation issue because similar inconsistencies have been recorded since 2003. Since maize is a main feed ingredient, this clearly impedes an adequate perspective of national feed use. The data from BPS is derived from yield surveys while USDA estimates are derived residually using the supply approach. Consequently, there are large diversions in the estimates of feed use between sources.

Most of the countries indicate that – beyond the deficiencies related to weak statistical systems that are characterized by poor data collection and limited collaboration between data collection agencies – data dissemination is plagued by many shortcoming and barriers in accessing data. This is caused by (1) the lack of a consistent and transparent data dissemination policy; (2) the lack of a single focal point for disseminating data and statistical information, i.e. data are frequently kept unshared in data collection units; (3) the published data are mainly aggregated indicators with limited disaggregation but not micro data; (4) most disseminated data are not accompanied by a clear description of the methodology used for collecting and calculating these numbers, which confuses data users.

Annex 2 provides a comparison between feed use data as reported by type of cereal (wheat, rice, coarse grains) and by source of data. The data presented are from national sources, FAOSTAT, USDA, and OECD/FAO for the “Outlook projections”. The data reveal the high variability between feed use estimates, not only between sources of data but among different types of grains. The variability of wheat and rice tend to be highest because feed as a share of the balance sheet is smaller, with shifts in use highly influenced by prices and the quality of the grain. By contrast, the coarse grains estimates tend to be less volatile and display similar trends across sources.

[11] Typically this type of information is subject to some publication restrictions.

VII. The way forward: Capacity building and investment

The AMIS goal is to enhance food market transparency and encourage policy coordination in response to market uncertainty. Within this context, the estimation of feed use of cereals has been recognized as one of the methodological challenges of participating countries, especially developing countries.

The country case studies clearly illustrate the need to improve statistics in the animal and feed sectors, especially in view of the speedy progress in production and processing technologies, rapid evolvement in organizational forms of production units, and continued extension of livestock and feed supply chains. Considering the importance of AMIS participating countries in the world cereals markets, investment in such initiatives would be of benefit to the countries themselves and the international community more broadly.

Improving the production of official statistics to the level of the developed countries would require initial public investment, supported by capacity building and short-term funding for annual operating costs, and in some cases comprehensive reforms on the mechanisms of governance. In the interim, the demand approach can be introduced as a methodological tool but the heavy data requirements necessitate a review of priority data investments in the individual countries. The case studies also reveal that preparation of cereal balance sheets more generally would require investments in statistical systems and better integration/dialogue between data collection agencies.

Possible innovations in feed/livestock data collection could be supported by the introduction of new and innovative on-farm surveys which facilitate the collection of some of the more problematic variables, e.g. on-farm feeding and technical parameters such as FCR. As suggested by USDA, the growing intensification of the livestock sector in the US and other countries may allow the use of more practical and cost-effective feed surveys. In the developing country context, these surveys could target and monitor “typical” livestock farms from each of the major livestock species. While not nationally representative, the indicators could be used to generate better estimates under the demand approach. Similarly, because farmers represent a much larger part of the overall population in developing countries, surveys on production/household consumption surveys should also include a question on the amount of on-farm consumption of cereals for food.

Overall recommendations to improve feed use estimation in AMIS participating countries include to:

- Review opportunities to harmonize methods for estimating feed use.
- Strengthen the use of cereal balance sheets, especially in developing countries, and review options to restructure national statistical organizations, supported by capacity building and seed investment.

- Review options for ensuring that the compilation of all elements of the balance sheet is under the responsibility of the same local agency, except trade which is already well covered by national customs authorities.
- Estimate cereal use for feed in the framework of a larger evaluation of the overall feed market in view of the numerous possibilities of substitution between cereals and other concentrate feeds. For this reason, the respective team should be composed of statisticians and economists.
- While strengthening the ability of policy makers to monitor sector developments through the use of cereal balance sheets, introduce the concept of calculating feed use using the demand approach
- Integrate the revised data into global systems to ensure global consistency.

Annex 1: Optimum FCR of different aquaculture species

Species	% of fish meal	% of other feeds[12]	Optimum FCR
Fed carp[13]	2-5	95-98	1.3
Shrimp	17.5-20	78-80.5	1.56
Tilapia	6	93.5	1.38
Catfish	10	88	1.07
Milkfish	3	96	0.8[14]
Other fresh water fish	10	88	1.07
Eels	55	40	1.42
Trout	30	55	1.25
Salmon	30	50	1.25
Pangas	10	90	1.07

[12] Fish oil is the additional feed when the sum is not equal to 100.

[13] Some other type of carps like common carp can feed themselves using natural nutrient present in the ponds. .

[14] Like some carps milkfish can feed themselves to a certain extent with natural nutrient and this was taken into account in the calculation of this FCR and explains why it is below 1.

Annex 2: Feed use data from multiple sources[15]

Feed use of rice (milled) from different sources (in 1,000 tonnes).

Countries	China			Indonesia	
Sources	BGAC	FAOSTAT	OECD/FAO	FAOSTAT	OECD/FAO
2000	5536	13403	10900	1640	600
2001	5336	15394	10700	1552	550
2002	5360	14794	10900	1977	550
2003	5360	12136	9500	1937	300
2004	5518	10159	9000	1339	300
2005	5676	8082	8900	1368	200
2006	5834	10114	8800	1481	100
2007	6258	10150	8600	1778	50
2008	6381	13153	8550	1516	50
2009	6421	13961	8500	1624	100
2010	6544		8500		110
2011	6670		8700		110
2012	6817		9000		110

	Philippines			India	
	BAS	FAOSTAT	OECD/FAO	FAOSTAT	OECD/FAO
2000	414	413	200	1700	1050
2001	433	432	350	1866	1100
2002	443	443	300	1437	750
2003	451	451	300	1771	600
2004	484	483	300	1663	300
2005	487	488	300	1837	300
2006	512	512	340	1856	300
2007	542	460	340	1928	300
2008	561	477	300	1985	300
2009	542	461	200	1784	100
2010	526		220		110
2011	557		230		120
2012	602		235		110

[15] OECD/FAO data are using in the Agricultural Outlook (see Box 1 on page 7)

	Thailand			Vietnam	
	NOS	FAOSTAT	OECD/FAO	FAOSTAT	OECD/FAO
2000	NA	862	840	332	715
2001	NA	935	950	290	715
2002	NA	934	880	387	821
2003	NA	983	900	392	794
2004	NA	952	850	403	753
2005	NA	1010	920	421	753
2006	NA	989	900	370	752
2007	NA	1071	950	352	763
2008	NA	1056	945	386	818
2009	NA	1071	950	599	831
2010	NA		1000		835
2011	NA		940		861
2012	NA		1100		893

Feed use of wheat from different sources (1,000 tonnes)

	China				Indonesia		
	BGAC	FAOSTAT	OECD/FAO	USDA	FAOSTAT	OECD/FAO	USDA
2000	6000	4058	4000	10000	108	250	0
2001	5800	5551	5500	9000	82	300	0
2002	6000	6058	6000	6500	129	298	50
2003	5800	5561	5500	6000	105	398	50
2004	4000	2555	2500	4000	136	497	50
2005	3500	3864	3800	3500	133	596	50
2006	5820	5649	5600	4000	138	596	50
2007	6800	6867	13500	8000	139	596	50
2008	6500	7049	9700	8000	135	546	50
2009	5000	7562	10500	10000	140	546	50
2010	6500		13500	13000		497	135
2011	16000		21000	24000		597	150
2012	20000		26000	25000		597	150

	Philippines			India		
	FAOSTAT	OECD/FAO	USDA	FAOSTAT	OECD/FAO	USDA
2000	200	800	950	916	800	2700
2001	300	800	1000	836	836	2700

2002	600	800	1250	964	871	2900
2003	500	700	950	819	788	2400
2004	550	350	550	912	864	2400
2005	530	350	850	857	823	2200
2006	500	360	500	914	830	2300
2007	300	150	50	942	907	2500
2008	250	350	1000	943	994	2500
2009	350	450	900	970	998	2800
2010		550	950		997	2900
2011		640	1375		996	3100
2012		680	1500		1246	3400

	Thailand			Vietnam		
	FAOSTAT	OECD/FAO	USDA	FAOSTAT	OECD/FAO	USDA
2000	0	200	310	0	0	50
2001	0	250	330	0	0	300
2002	0	200	275	0	0	375
2003	0	230	270	0	0	275
2004	0	200	260	0	0	350
2005	0	250	280	0	0	150
2006	0	300	300	0	0	325
2007	0	270	150	0	0	300
2008	0	250	200	0	0	200
2009	0	400	400	0	0	750
2010		500	700		0	850
2011		1300	1300		1000	1100
2012		950	1000		1000	350

Feed use of maize from different sources (1,000 tonnes)

	China			Philippines		
	BGAC	FAOSTAT	USDA	BAS	FAOSTAT	USDA
2000	87450	93931	92000	2932	3650	3400
2001	90080	92212	94000	2941	3725	3200
2002	91880	94079	96000	2807	3906	3150
2003	91900	95072	97000	3000	3975	3450
2004	92000	96853	98000	3518	3945	3600
2005	93500	99470	101000	3414	3750	4200

2006	96000	97572	104000	3953	3953	4950
2007	94800	99932	106000	4379	4379	5350
2008	96800	104113	108000	4503	4503	5300
2009	105800	104512	118000	4572	4572	4500
2010	109000		128000	4145		5100
2011	112000		131000	4531		5300
2012	115000		144000	4815		5400

Feed use of coarse grains from different sources (1,000 tonnes)

	China			Indonesia		
	FAOSTAT	OECD/FAO	USDA	FAOSTAT	OECD/FAO	USDA
2000	98312	92895	94377	3038	3000	3600
2001	96217	90061	96300	3267	3000	3600
2002	97759	92318	98410	3465	3194	3900
2003	99028	92385	99100	3329	3593	4000
2004	100288	94362	100320	3517	3532	4000
2005	103101	96956	103500	4016	3792	4200
2006	100752	99855	104850	4010	4441	4100
2007	102588	103999	106700	4213	4441	4200
2008	106489	106602	109050	4412	5489	4400
2009	107087	109418	119100	4511	7487	4500
2010		115112	128750		8588	5400
2011		121033	132400		9087	6000
2012		130971	146100		9521	6400

	Philippines			India		
	FAOSTAT	OECD/FAO	USDA	FAOSTAT	OECD/FAO	USDA
2000	3669	3167	3416	4182	6650	7160
2001	3737	3158	3204	4399	3703	8050
2002	3918	3009	3154	4017	3055	7050
2003	3991	3077	3473	4445	4190	8100
2004	3960	3432	3608	4474	3888	8400
2005	3768	3732	4206	4571	4016	8100
2006	3975	4678	4957	4772	4099	8600
2007	4403	5029	5376	5111	5101	9300
2008	4539	5220	5318	5291	5232	9800
2009	4604	5380	4512	4491	4472	9600

2010		5330	5116		5788	11750
2011		5330	5313		5721	11650
2012		5330	5420		5411	11200

	Thailand			Vietnam		
	FAOSTAT	OECD/FAO	USDA	FAOSTAT	OECD/FAO	USDA
2000	436	3856	4395	1526	1600	1537
2001	366	4041	4394	1496	1800	1767
2002	347	3860	4090	2002	2125	2150
2003	327	3321	3520	2432	2653	2200
2004	274	3505	3640	2701	2700	3100
2005	271	3541	3960	3102	3100	3400
2006	255	3334	3525	3402	3600	3850
2007	334	3323	3725	3702	4379	4200
2008	408	3819	3740	4002	4750	4300
2009	385	3834	3830	3852	4800	5100
2010		4380	4240		4950	4800
2011		4501	4550		5000	5000
2012		4430	4840		5000	5200

Annex 3: Summary of country reports

China

China is now the largest consumer of feed ingredients in the world, accounting for one-fifth of estimated global totals. The fast growing economy associated to a strong positive income elasticity of demand for meats, fish and dairy products has led to a rapid growth in consumption of these products. Most of the growth in consumption has been met by growing local meat and dairy production[16], resulting in a very rapid increase in feed consumption. This phenomenon was accelerated by a shift from small holding production units often using waste as feed to large scaled commercial operations using concentrate feeds. Having good information on the amount of feed products consumed in China is not only necessary for a good understanding of the Chinese market but also for a good understanding of the world market considering China's dominant position in that market.

Unfortunately, China's official system for agricultural statistics is very complicated. Under the current system, the National Bureau of Statistics (NSB) is the only agent authorized to release official statistics. For agricultural statistics, the NSB conducts large-scaled household sample surveys (the first methodology) to collect a wide range of information like production, sale, selected usages and on-farm stock of cereals. However, the samples are very small relative to the national population and are challenged by lack of institutional cooperation, leading to significant biases, especially as regards production figures. For cereal production, the NSB recently adopted a method by which yields are calculated using sample plots that are verified by NSB staff instead of by local authorities who had a tendency to introduce upward bias in the statistics. Production is derived from yields and area estimates. The end results are still negotiated by provincial governments and other institutions until a consensus is obtained. But all of these efforts lack coordination and there is no official cereal balance sheet published by China in which feed use could be calculated residually or be checked for consistency with the other variables.

Non-official statistics related to animal production and feed use are also produced by quasi-public institutions and private consulting firms. However, none of them has adequate financial and human resources to conduct nationwide statistical works in a way comparable to the NSB and more importantly, they have no administrative authority. With respect to cereal information, the Chinese Association of Feed Industry publishes the China Almanac of Feed Industry annually. This Almanac covers only statistics of manufactured feed production and does not cover raw materials used or on-farm feed leaving the users with incomplete information. Another institution, the National Center for Grain and Oil Market, compiles balance sheets of major cereals and oilseeds, but that information is supplied on a commercial basis (paid subscription). That Center uses the official production data from NSB and

[16] Since oilseeds are crushed in China and therefore the resulting oilseed meals are considered a locally produced feed ingredient.

trade data from custom authorities. Based on the Centre's linkage with the industry they impute the rest of the balance sheet including feed use.

The two main methods of imputation are the demand (or animal requirement) approach and the supply (or balance sheet) approach. For the demand approach, the results rely critically on the accuracy of animal inventories and/or production data, and on feed conversion ratios (FCR). The sampling survey used to calculate meat production in China can lead to an over-estimation because it takes into account animals sold multiple times. The feed conversion ratio depends critically on the type of operations. The data on feed conversion ratios for different animals by scale of operations can be obtained from production cost surveys done by the National Development and Reform Commission (NDRC). Feed use surveyed in these reports excludes on-farm feeding, and for that reason would only be representative of the farms using exclusively concentrate feeds. The fact that China uses an increasing share of high-protein feed in the rations is an indication of an improvement in the FCR. However, since specialized and commercial farms using concentrate feeds are replacing backyard farms, which are partly using waste, the FCR of concentrate feeds[17] of the entire country will not improve as rapidly as the one in the commercial farms.

According to the model of Chinese agriculture maintained by USDA and available in the OECD AGLINK database system the share of production originating from backyard farm differs from one species to another. Dairy is the lowest with around 15 percent followed by poultry and eggs at around 40 percent, followed by pork at 60 percent and beef at about 75 percent. In aquaculture, carp is by far the largest species produced, of which 40 percent is common and grass carp, which can be fed from the natural nutrients in the water. The second largest group is mollusks which are fed with natural nutrients in the ocean. Shrimp and tilapia productions are much smaller, but consume a larger proportion of concentrate feeds. Considering all this anecdotal information, OECD estimates that pork production requires as much feed as the sum of all the other animal production. The second largest consumer is poultry and eggs, followed by milk, aquaculture and beef.

For the supply approach, assuming that production and trade data are good, the feed estimates depend critically on the quality of data on "other uses" and stocks. But since data for "other usages" are as poor as that for feed, and changes in state stocks are difficult to measure, this approach is not ideal in China.

Tian Weiming in his analysis of the feed market in China concludes that "past experiences indicate that China's statistics on animal production are subject to systematic errors… China has no systematic statistics on feedstuffs…"the real barriers for China to produce reliable statistics are institutional."

[17] The FCR of all dry matter including waste would on the contrary improved (i.e. get smaller) as low quality feeds are replaced by high quality feeds.

India

The report "Animal feed resources and their management in Asia Pacific region - an Indian perspective" by Anadan et al. reviews the key animal production sectors, documenting them in terms of type of operations and FCR. It appears that India has the data and systems in place to evaluate the feed requirement of poultry and eggs production. For pork production, information on farms feeding pigs with waste is needed and only anecdotal evidences are given for ruminants.

India hosts the largest herds of dairy cattle and buffalo in the world, indeed representing the largest animal sector in terms of economic value and quantity of feed consumed. Cattle and buffalo are followed by poultry, aquaculture, sheep and goats, and pigs. Feeding systems in smallholder dairy farms are primarily based on grazing of native pastures of low nutritive value. In India, cattle and buffalo are usually fed on wheat, paddy rice and millet straws and stovers, and from sugar cane tops. These are supplemented with small quantities of grass. Generally very little amounts of concentrate feeds are fed to the growing, working, pregnant or non-lactating animals. Only lactating animals are given better feed rations through the provision of by-product concentrates such as oilseed cakes, brans, and milled pulses. Depending on the agro-climatic region, season and stage of production, the proportion of feed components varies in the ration of animals. Anadan reported in a study published in 1997 that grasses from grazing counted for 15-30 percent, crop residues, for 66-70 percent, cultivated forages, for 5-8 percent and concentrate feeds for 2-5 percent. Considering the shortage of pasture for grazing and forages, it would not be surprising to discover that the proportion of concentrate feeds has increased over time. In 2012-13, only 7 million tonnes of cattle compound feed was produced in India. Cereals counted for 10-15 percent of the ingredients used in these mixes, bran 35-45 percent, protein meals 25-35 percent, molasses 8-10 percent and the rest is other food by-products, minerals and vitamins.

Most of the poultry production in India is done by commercial operations that have achieved similar FCRs as in developed countries (i.e. around 1.8). Commercially, it is estimated that around 8.1 million tonnes of layer feed is produced, of which around 85 percent of the total is prepared by farmers and the rest comes from the compound feed industry. In the case of broilers, it is estimated that around 10.9 million tonnes of feeds is produced, of which almost 80 percent is produced by the feed industry in pellet form and the remaining 20 percent is produced in mash form by the farmers. The most important ingredients in theses mixes are maize, oilseeds meal, cereal by-products and molasses.

Aquaculture, which counts for almost two thirds of fish production in India, has shown significant growth in the last two decades and has transformed itself into an industry contributing substantially to food production. A wide range of freshwater, brackish water and marine aquatic organisms are produced in India. The major groups are freshwater fish and prawns, penaeid shrimps, crabs and brackish water fishes. In

large freshwater bodies extensive fish culture is done on natural food available without the application of external inputs. In semi-intensive and intensive fish production systems, supplementary feeding is provided in addition to the application of fertilizers to improve natural productivity. Less expensive feed ingredients such as rice bran, wheat bran and groundnut cake are extensively used for feeding carps in freshwater aquaculture. Fishmeal and defatted oilseed cakes (soybean, mustard, and sesame and cotton seed) are also used when higher protein feeds are needed. Animal by-products such as meat and bone meal, blood meal are occasionally used. Trash fish, poultry offal and other animal by-products are used for carnivorous fish cultures. Both conventional and non-conventional feed ingredients are used in formulating feeds for shrimp and giant freshwater prawn. Feed ingredients of marine origin such as fishmeal and fish oil are extensively used in shrimp and prawn feed formulations. The FCR of these aquatic species is in the range of 1.2 to 1.4 for the different fish, and 1.2 to 1.5 for the different shrimps. Both farm-made and compound feed are used extensively and the proportion varies by species. In shrimp feed the main ingredients are fish and soybean meal, wheat, rice and fish oil. In fish feed the main ingredients are oilseeds meal, maize, bran, manioc and meat, blood and bone meal. It is estimated that annual consumption of concentrate feed by the aquaculture sector is approximately 8.3 million tonnes, ranking third in the consumers of concentrate feeds in India, behind dairy and poultry.

The major limiting factors in improving sheep and goat production are lack of pastures and fodder shrubs, and trees in the area where the sheep and goats abound. Against this background it is possible that the very low share of concentrate feeds in the ration may have increased over time. Very small amounts of concentrate feeds are given to pigs in India. First, indigenous pigs, which count for the major part of the inventory, are reared under a free-range scavenging system with little or no inputs. Second, those raised in intensive systems are being feed on some concentrate feeds, hotel and kitchen waste, vegetable wastes and root crops.

Two other particularities of India are that ruminants are able to feed themselves in forests by eating available grass and leaves, and that fallow land is almost three times larger than permanent pasture.

Indonesia

Feed use estimates are particularly challenging in Indonesia because production data, at least for maize, is subject of controversy. The Central Board Statistics (BPS) of Indonesia reported that maize production in 2012 was 18.96 million tonnes while USDA reported only 8.9 million tonnes, a difference of 10 million tonnes. This is not due to a preliminary evaluation issue because similar inconsistencies have been recorded since 2003. According to the country case study, there are no time series for feed use of cereals from local sources.

Ruminants (cattle feedlot and dairy) reared in intensive systems are fed few grains but only locally available by-products such as rice and wheat bran, cassava waste, palm kernel meal and copra meal, which are easily accessible and more economical than maize. Other ruminants are raised in semi or extensive systems with no access to grain. Aquaculture, especially shrimp, is not fed with grain, while fish feed uses very little grain due to nutritional reasons. However both use other concentrate feeds. Evaluating non-ruminant feed requirements is further exacerbated because of different feeding practices, inconsistencies in the broiler production data, and difficulties in estimating feed conversion ratios by species and type of operation.

Philippines

The Bureau of Agricultural Statistics (BAS) of the Department of Agriculture of the Philippines produces a very comprehensive database of agricultural statistics. Data on production originating from backyard farms is available since 1994, and complete balance sheets are available since 1990, at least for maize and rice. So contrary to other countries, the Philippines produce official statistics on feed use. The country is able to use the supply approach to calculate feed use of maize and rice as regular surveys of stocks and production are available.

There are five major feed consumers in the Philippines; pig, chicken (for meat and eggs), duck (for eggs), fish and shrimp. Cattle and goats are raised primarily from pasture. The proper link between production of these species and feed consumption depends also on the type of operation (backyard and commercial farms). For pigs, which are by far the largest consumers of feed, the share of production from backyard operations has fallen from 81 percent in 1994 to 65 percent in 2012. Poultry, the second largest feed consuming species, has experiences a similar development, with shares falling from 59 percent to 47 percent over the same period. Finally, according to estimates made by the author of the country case study, the amount of feed used by the aquaculture sector has almost doubled over the past twenty years.

Thailand

Thailand is one of the world's largest food producing and exporting countries. The major livestock industry species are chicken, swine, dairy cattle, beef cattle with goat and sheep occupying a very minor composition. Broiler products are the main commodity for export while other non-ruminant species and ruminant are produced for domestic consumption and small-scale trading.

Several national statistical institutions as well as associations collect, compile and report feed-related data, including the Department of Livestock Development (DLD), the Office of Agricultural Economics, and the Thai Feed Mill Association. Three distinct models have been identified in the country report to compare and estimate food-feed production, feed supply and feed demand.

The Thai Feed Mill Association regularly published a report on animal feed demand based on livestock production and feeding rate. In addition, the DLD feed assessment model estimates feed use and demand as well as nutrients requirements of each species/type of livestock. This model was developed by DLD and the Ministry of Agriculture and Cooperatives, in collaboration with ten universities and research institutions.

Vietnam

Similar to the other countries analyzed in this report, the amount of cereals used for feed is not available through the Vietnamese statistical system. The calculation of production seems to be statistically sound, and trade data are available from customs authorities. The challenge remains distributing the other elements of demand in the balance sheet, i.e. feed and food use and ending stocks. This task is exacerbated by the fact that roots and tubers are an important source of animal feed, generated by large cassava and sweet potato production. Similar to the situation in India, ruminants are extensively fed with crop production residues such as sugar cane and maize leaves. Finally, the animal product sectors make extensive use of non-conventional feeds, including restaurant waste, fish trash and other residues from the food chain. Aquaculture is also often carried out in combination with rice or pig farms to minimize the amount of concentrate feeds needed by the fish. Knowing the proportion of animals that are fed with non-conventional feeds is essential for a sound evaluation of cereal use for feed. Presently, at least 13 million tonnes of feeds are consumed as this amount corresponds to the production of compound feed.

Pigs are the leading consumers of feeds in Vietnam followed by broilers, layer hens and aquaculture. Even though ruminants (cattle, buffalo and dairy cows) only count for a small proportion of the overall feed demand, the lack of pasture land forces Vietnamese farmers to make greater use of concentrate feeds. In 2008, 24 percent of pork production was carried out in commercial farm versus 76 percent for household farms. In 2011 the share of production originating from commercial farms had jumped to 45 percent. For poultry, this share increased from 22 to 35 percent over the same period. For cattle, commercial operations remain low at 15 percent in 2011. In aquaculture, many feeding practices coexist, including rice-fish, rice-prawn, pig-fish and monoculture fish in extensive, semi-intensive and intensive mode. Calculating how much cereals are consumed by the aquaculture sector in Vietnam is therefore a challenge.

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