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1. Background

This is one trend that cannot be ignored. Growth in the production and consumption of milk and milk products in Asia has consistently outpaced the growth in other regions and Asia has now overtaken Europe as the world’s largest milk producer. India is currently the largest producer of milk accounting for 19 percent of global production. According to OECD FAO Outlook 2015, global milk production is projected to increase by 175 Mt (23%) by 2024 when compared to the base years (2012-14), and the majority of which (75%) is anticipated to come from developing countries, especially from Asia (OECD-FAO Agricultural Outlook 2015-2024). This opens new opportunities which we must seize and throws at us new challenges that call for concerted action from politicians, scientists, industry captains, producer organizations, development agencies, academia and the larger civil society.

Traditionally, the dairy sector in the region, particularly in South Asia, has been characterised by smallholder integrated production systems with most producers maintaining between two and five cows. Although the recent years have seen broad-based scaling up throughout the region and emergence of corporate-style mega farms in East and Southeast Asia, traditional smallholder systems remain dominant. At the same time, two thirds of the world’s 800 million undernourished people live in the Asia-Pacific Region. One daily glass of milk to the children in Asia can contribute tremendously to improving the nutritional levels in the region.

The existence of a vibrant smallholder-managed dairy sector combined with a robust medium term market outlook is good news since the poor generally tend to be much more important in smallholder dairy/livestock production than in crop production. Dairying is also more labour intensive than crop production and provides a remunerative outlet for family labour. These characteristics imply that
growth in smallholder dairy can have a more direct and greater impact on poverty reduction. If production can match the growth in demand, dairying can emerge as an engine of poverty-alleviating growth with all other nutrition related benefits.

However, with increasing complexity of dairy production and distribution, constantly changing consumption demands, deepening regional and global integration, diverse expectations from the sector and growing public health and environmental concerns, the region faces many challenges in dairy development. Some of these include

- Improving productivity and profitability along the cow-to-consumer dairy food chain and at farm level
- Improving the organisation of smallholder milk producers to improve their bargaining power and reduce risks
- Improving dairy food quality and safety
- Encouraging public and private sector investment in dairy value chain
- Maximising smallholder earnings from dairying in a manner that minimizes harm to soil health and contribution to water and atmospheric pollution
- Strengthen stakeholder capacity to cope with production and market risks and for innovation
- Minimize the environmental footprint of the dairy sector and improve mitigation/adaptation measures

The investment, institutional development and policy requirements for supporting balanced dairy sector development in the region are quite complex. Dealing with such complexities requires strategic focuses on priorities and policies that encourage investment in productivity enhancement, efficient and equitable distribution systems, development of tools, methods and systems to monitor animal, public and environmental health, an enabling policy environment and development of complex institutions to steer the balanced development agenda. It is important to recognize that a public sector or quasi-public sector input in the supporting dairy value chain development is needed to bring about diagnosis of the needs and to find the solutions. There are many questions on how best to supply an enabling environment and provide the dairy value chain agents with inputs, credit, new technologies and skills. Answers to such questions would be context specific and would require a careful analysis of production systems, cost structures, prices and trade patterns, efficiency and equity implications of various
models, and the natural resource and environmental implications of expanded dairy production and consumption in the region.

In the light of the foregoing, this paper attempts to present an initial analysis of some of the available data and knowledge on economic and policy relevant parameters of dairy production in the region. The purpose is simply to provide some background information on policy relevant parameters and to stimulate discussion on how countries and stakeholders can work together on enhancing the knowledge about dairy economics and policy under the broad umbrella of Dairy Asia and how this can be leveraged for better dairy policies in the region.

2. Production systems, and cost structures

Milk production systems across Asia are varied in terms of structure of production, scale and level of intensification, all of which is reflected in the economics of production. This variation is a function of differing agro-climate zones, level of development and infrastructure between countries, but also due to contrasting traditions of milk production and cattle keeping generally in different parts of the region. As noted earlier, dairy production in South Asia is typically relatively small scale, mostly local or cross breed cattle or buffaloes, low input and output in nature, and depends largely on crop residues. In SE and East Asia somewhat larger scale and more intensive production systems are often observed, with greater use of planted forages and higher grade exotic dairy cattle. In all parts of the region there are exceptions in the form of industrial scale production units in some locations. The map of the livestock production systems in Asia below is very indicative of the factors underlying some of the regional differences. South Asia exhibits semi-arid but often irrigated areas, while SE Asia is more humid and rainfed. In this section we examine the implications of the structure of farm production and associated yield levels on costs of production and competitiveness.
In spite of the variations in systems across the region, there are nevertheless some commonalities that can be observed across Asia that have implications for the economics of production. These include relatively low yields, relatively small production units compared to other regions, and also low costs of production in most cases.

**Yields**

Data from the International Farms Comparison Network (IFCN) show that milk yields across the region are generally low as seen in figure 3. China and Thailand exhibit the highest yields at 3-5 MT/cow/year reflecting the generally more intensive production systems, greater use of improved technology and higher proportion of concentrate feed use in those countries. Everywhere else however, yields remain relatively low, under 2 MT/cow/year, and in several countries particularly in South Asia including the largest producer India, yields are 1 MT or lower.

These comparisons much however be put in the context of differences in production systems as milk production in South Asia relies more heavily on crop and agro-industrial by products hence minimizing the pressure on natural resources. What is important is to examine the trends of milk yield improvements...
within the context of similar production systems. However, even within countries, there seems little evidence that yields are significantly improving in recent years except in a few cases such as China and Vietnam, the latter case likely evidence of large private sector investment in intensive dairy production and induction of large herds of exotic animals. Everywhere else yield growth was either flat or growing at a very slow pace. This suggests that overall growth in dairy production has been driven mainly by growth in numbers of animals, as can also be confirmed in FAOSTAT figures.

![Bar chart showing milk yield comparison](chart.png)

**Figure 3:** Comparison of milk yield in Asian countries from 1996 to 2014

To be sure, considerable yield gaps do exist in large part of the region. For example, yield gaps in South Asia are illustrated in the figure above. This analysis compares “like with like”. Rather than comparing averages of cattle of all types, yields from similar breed compositions in similar production systems are compared, using data from individual case studies reported in the literature. Differences can thus be attributed mainly to management and environment, including climatic and disease challenge. What is observed is wide variability in yields even of similar breeds in the same general production systems. Yield gaps of over 100% are observed among indigenous breeds, and from 63% to over 300% among crossbreds. These yield gaps do have implications for returns from milk production, but are unlikely to translate directly into differences in costs, since low yields are likely associated with low input and low cost systems. Although the data may mask differences in specific animal genetics and feed quality, etc. the variations in yield
do nevertheless point to important opportunities for improved competitiveness, and suggest that some producers may be significantly underperforming their potential. This underperformance should be a priority target for research and development investment towards improving the competitiveness of Asian dairy, particularly in South Asia where yields are lowest at the same time that dairy animal populations are the largest.

**Figure 4:** Milk Yield Gaps across production systems and breed composition (Staal et al., 2010)

**Number of dairy farms and farm size**

The number of dairy farms worldwide 2014 is shown in Figure 5. In total, there are 121 million dairy farms worldwide, India being the country with the highest number of farms (76 million), followed by Pakistan with 7.1 million. The average herd size averages 2.9 cows per farm, ranging from a single cow to several 10,000 cows.

**Figure 5:** Number of dairy farms worldwide in 2014
As in many other tropical developing countries areas, dairy farms in Asia are often depicted as small compared to global averages. This stereotype is being increasingly challenged by public perception given the high profile that large scale dairy development investment often receives. However, the available data suggest that the stereotype remains generally true, depending on one’s definition. Data collected by IFCN in the figure below (Figure 6) indicate that during the period 1996 to 2014 dairy farms in key Asian countries show that farm sizes (cows/farm) are mostly less than 10, and in the major producing countries of South Asia, farms generally have fewer than 5 cows. The phenomenon driving this is generally understood, although disputed by some. When the off-farm opportunity costs of labor are low, under-utilized family labor and crop residues can be used to raise dairy cattle, often in a complementary or supplemental manner with crops or other enterprises, limiting herd size to avoid hiring more expensive wage labor and the buying of feed. Land, capital and feed scarcity also play roles. As labor becomes more expensive, there is incentive to shift to improved breed animals, and more efficient labor practices that generally require larger herds and typically greater degrees of mechanization. As evidence of this, Staal (2001) found a strong correlation between cost of wage labor and dairy herd size across a number of developing countries. We return to this in the discussion of cost of production below.

![Figure 6: Average number of cows per farm in Asian countries from 1996 to 2014 (IFCN data)](image)

Cost of milk production
As mentioned above, wide differences in yields may not necessarily translate into large differences in costs and particularly of returns per 100 kg milk. Hemme et al (2014) have undertaken some analysis of costs of production globally using typical farm case studies, and IFCN’s standard farm budget template. In the IFCN, a typical farm represents a certain production system, farm size, production technology used and the related milk volume in a country / dairy region (Hemme, 2000). In order to ensure comparability, IFCN uses a standard uniform method called “Typical Farm Approach” (TFA). The details of the method are available in the methods section of http://www.ifcndairy.org. The basic indicator to measure cost competitiveness of typical dairy farms is the cost of milk production only, which refers to the total costs of the dairy enterprise from which the non-milk returns have been deducted. Hemme et al (2015) showed that the cost of milk production in 2014 is generally lower in South and SE Asia than elsewhere, generally in the range of 20-40 US$/100 kg, and similar to the levels found those in Oceania as seen in figure 7. These are among the lowest costs found anywhere globally, and are likely to be related to the low input-low output system described above, using underutilized family and land resources (and related to available low cost pasture in Oceania). China exhibited higher levels of costs, around $50 - 60/100 kg. Feed was found to be the first determinant of costs, followed by labor (Hemme et al 2014).

Figure 7: Cost of milk production only on average sized farms in 2014 in USD/100 kg ECM (IFCN Dairy Report 2015)

Some have suggested, and many assume it to be true, that there are economies of scale in milk production, which is the driving principle behind many dairy development interventions that aim to industrialize production or at least promote larger farms. However, evidence from a number of studies in developing countries
have challenged that assumption (Sharma et al 2003, Omiti et al 2006), and generally found few economies of scale in studies in multiple countries in Asia, Sub-Saharan Africa and even South America at the production level, but did find economies of scale in marketing and processing. Hemme et al (2014) also find no general association between farm size and the cost of production using data from 46 countries, both developing and developed. There are of course exceptions, such as the study by Ma et al 2012, that used a Total Factor Productivity approach, and found scale efficiencies on Chinese dairy farms. In similar settings, one approach to seek scale efficiency by businesses in China is the leasing of dairy cows from farmers, reducing upfront investment and still allowing growth. (Wang et al). Such approach may have relevance particularly in rapidly developing contexts.

The point here is first that cost of milk production is generally low in much of Asia and that scale is unlikely to be a critical determinant. Instead, resource factor values in terms of land, labor and feed generally determine which scale of production is relatively most efficient in a given system at a given time. This has important implications for targeting investment and requires a more nuanced approach than just aiming for scale, and instead recognizing the limiting factor in each setting.

3. Markets, prices and trade policies

Asia exhibits a wide of dairy market and value-chain arrangements ranging from rural village markets to traditional retail outlets to informal or traditional vendors selling fresh milk or traditionally products to highly sophisticated and integrated processor and supermarkets networks. The emergence of supermarkets and their impact on the production landscape has been a subject of intense policy debate in the region but the informal and traditional markets are often left out of policy attention and in the case of dairy, the role of supermarkets may be different. According to some estimates, nearly 60 percent (and in some countries more than 80 percent) of consumers purchase dairy products in informal or traditional markets and only occasionally consume processed or semi-processed products, some of which are also traditionally processed. In the case of dairy in East and Southeast Asia, the share held by informal markets however is much less than in South Asia. This is all occurring in the context of very rapid growth in demand for milk and dairy products across the region, particularly in E and SE Asia as incomes
rise and consumer tastes change. Imports of dairy products in some parts of the region are large and growing.

Demand and supply and trade implications
Growth in demand for dairy products in Asia is well documented, and was first globally highlighted by Delgado et al as the Livestock Revolution. Recent (January 2016) projections were made using IFPRI’s IMPACT model (Robinson et al 2015) to 2050. The projections to 2050 are strongly influenced by regional distributions. East and Southern Asia, in 2010 and projected to continue in 2050, together account for more than 80 percent of milk production in Asia. Southeast Asia represents only about 3 percent of the total of both demand and supply. The projections show that between 2010 and 2050 demand for dairy products in Asia overall will increase by over 75% to over 500 million MTs from less than 300 million in 2010. This growth is strongest in East Asia where demand is expected to grow by 95% to 2050. China’s dairy market has expanded rapidly in the past two decades but there are significant disparities across regions and income groups (Wang et al). However, dairy demand is also growing in other parts of Asia. Demand growth in South Asia is expected to be around 75% while growth in Southeast Asia is expected to be in the range of 50%. Even though demand growth in East Asia will be largest in percentage terms, total demand in South Asia will comprise some 300 million MTs in 2050, double the 150 million MTs in East Asia.

Figure 8: Net exports dairy products 2010 and 2050, ‘000 MT (Dolapo 2016 analysis based on Robinson, 2015)
The Figure above illustrates the import/export implications of these supply and demand projections. Asia overall in 2010 was and continues to be a large net importer, over 20 million tons, largely driven by East and Southeast Asia (imports are depicted in the graph as negative exports). South Asia, currently a relatively small net importer, is projected to shift dramatically to become a significant exporter by 2050, exporting nearly 30 million tons. The overall outcome will be that Asia will be a smaller net importer overall, but imports will increase enormously in East Asia, and to a smaller extent in Southeast Asia. A key question is the extent to which the increased demand in East Asia will be met by exports from South Asia through intra-regional trade, or will still rely on imports from Australasia and elsewhere. Further enabling such trade would require reducing formal and informal trade and business obstacles, but would also be heavily dependent on issues of product quality and consumer perceptions of that, in addition to basic relative transport costs within the region. Also OECD and IFCN undertook some analyses of the Asian dairy market. Breaking down South Asia into different regions within countries shows that already right now South Asia consists of net importing and net exporting regions (Figure 9). The world milk price is the driver for milk surplus and deficit regions.

![Figure 9: Milk surplus and deficit regions 2014 (IFCN Dairy Report 2015)](image)

The table below illustrates tariffs on dairy products in some key countries. What is apparent is that Southeast Asia has taken stronger steps towards reducing trade barriers than has South Asia. In addition to the fact that the ASEAN Free Trade Area came fully into effect at the end of 2015, essentially making the region duty-free for sub-regional trade, applied Most Favoured Nation (MFN) tariff rates have remained low in most of the ASEAN countries. There is a strong reason to believe
that the relatively low tariffs have led observed recent increased value of intra-ASEAN trade in dairy (Daite et al 2013). South Asian countries have maintained somewhat higher tariffs, presumably due to their position as major milk producing countries.

**Table 1:** Tariffs (in percent) on Dairy Products in Asian Countries (World Tariff Profiles 2015 and WTO Tariff Profiles; ASEAN Tariff Schedules)

<table>
<thead>
<tr>
<th>Country</th>
<th>Final Bound Duties</th>
<th>MFN Applied Duties</th>
<th>Range of Rates in ATIGA***</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>AVG</td>
<td>Max (%)</td>
<td>Binding (%)</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>157.5</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>India</td>
<td>65.0</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>Nepal</td>
<td>45.8</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Pakistan</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>48.5</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>China</td>
<td>12.2</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Indonesia</td>
<td></td>
<td></td>
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<tr>
<td>Malaysia</td>
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<tr>
<td>Myanmar</td>
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<tr>
<td>Philippines</td>
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<tr>
<td>Thailand</td>
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<tr>
<td>Viet Nam</td>
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</tbody>
</table>

* As of 2008; ** As of 2011; *** ASEAN Trade in Goods Agreement

Even if tariffs are reduced, Non-Tariff Barriers (NTB) and Measures (NTM) may continue to present obstacles, although the quantification of these effects is difficult. There are four major groups of NTMs that are of interest: (1) technical barriers to trade; (2) sanitary and phyto-sanitary standards (SPS); (3) customs related measures; and (4) the so-called “core NTMs”. Core NTMs are defined as those pertaining to non-automatic licensing; quantitative restrictions; prohibitions; enterprise-specific restrictions; single channel for imports; and foreign exchange market restrictions.

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5 **NB:** Bound tariffs is the maximum rate of tariff allowed by WTO to any member state for imports from another member state while applied tariff is duty actually charged on imports and may be below the bound rates.
The projections demonstrate that there will be enormous opportunities in coming decades for Asia to gain overall through intra-regional dairy trade. ASEAN has undertaken steps that in 2015 created a single market, but barriers remain to intra-regional trade between South and East. Dairy policy makers will be required to engage closely with other decision makers in order to exploit these opportunities particularly to reduce NTBs, including trade ministries, SPS and veterinary regulators, consumer and producer interest groups, among others.

Prices
Milk prices paid to farmers are dependent on a number of factors, including the prices of imported competing dairy products, local market demand and supply, distances and transport costs to market points, and the cost of production, among others.

**Figure 10:** National milk prices (USD/kg) in Asian countries 2005 to 2014 (Derived from IFCN Dairy reports)

National farm gate milk price data derived from various IFCN dairy reports are displayed in Figure 10, and are compared to the international milk price. International prices spiked in 2007 with the global food price crisis that occurred around that time, but that increase was not consistently reflected in national milk prices, except in the Philippines and Vietnam for example, most likely reflecting their large dependence on imports. In subsequent years prices climbed mostly gradually and in some cases stabilized. Of interest is that prices vary widely between Asian countries, in addition to differing from international prices. In major
producing countries such as India, prices in national currency have increased steadily since 2007 (Figure 11). The national milk price in India has been considerably below the world milk price for many years, only during the current crisis managed the milk price to stay on the high national level high above the world milk price.

Figure 11: India’s prices in relation to world milk prices Jan 2006-Feb 2016

The underlying factor for the difference in national and world milk price is that milk and dairy products generally can be regarded as only semi-tradable products, particularly fresh milk, which in some markets constitutes the large market share. Generally only some 10% of dairy products produced globally are traded across international boundaries as a reflection of this fact. This means that prices are mostly determined by local supply and demand factors, not international prices. In countries with large informal milk markets, and where consumer preference is generally towards fresh raw milk and traditionally processed local products, that product differentiation creates a natural buffer against imported processed products, which consumers may not regard as close substitutes in many cases. This “natural protection” from imports has been demonstrated in other markets for fresh livestock products as well (Tisdell et al 2010).
Conversely, raising food safety standards may have little influence on imports. A study by Sun et al (2014) found that changes in food safety standards of dairy products have no effect on China’s dairy imports, largely because China’s safety standards are relatively lower than that in its major exporters.

These differences mirror closely the discussion above regarding differences in costs of production among countries. Because costs and prices are mostly locally determined, and not overly influenced by international factor and product prices, differences between countries do not necessarily reflect market distortions. Policy makers may instead concentrate more usefully on differences within local markets along local supply chains, which will be influenced by the degree of market concentration, collusion between market actors, retail networks, but also transport infrastructure that disadvantages rural producers.

**National and local dairy markets**

As mentioned in the introduction, national dairy markets in Asia are extremely diverse in terms of the types of products, supply chains and linkages, and market actors. While East and Southeast Asia exhibit mostly formalized milk markets that rely on modern processing technology and typically apply modern HAACP protocols comparable to countries in the North, South Asia is mostly characterized by informal or traditional markets supplying raw or traditionally processed products. There are few reliable statistics, but estimates indicate that 80% of the milk in India flows through these channels and more than 90% in Pakistan. In Sri Lanka the figure is closer to 40%. This is not unique to the dairy industry in such countries: the informal economy overall is reportedly half of India’s GDP and employs 90% of its workers (Credit Suisse 2013 from ISAE paper) In those countries with large informal markets there is nevertheless a duality in the simultaneous existence of formalized markets applying modern process, which are in all cases observed generally growing in market share. Cooperatives also play an important role in some cases, such as in Thailand with more than 90% share of locally produced milk. In India, the formal market is now estimated to be split about evenly between cooperatives and private dairy enterprises, as the private share has grown in recent years (Karmar et al). School milk programs such as in Thailand may also play an important role in local milk markets, and also serve to create milk consumption habits among youth that can drive future demand.

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6 Hazard analysis and critical control points
The phenomenon of informal or unorganized markets for milk, and for any other product for that matter, is driven by a significant gap between buyer demand for product characteristics, and the standards in the formal market for those characteristics, generally imposed by regulatory authorities. Imposing higher quality and safety standards always implies a higher cost and retail price for the product. When consumers are unwilling to pay that price and regard the cheaper raw or traditionally processed product as an acceptable substitute, the market forces will ensure that the informal market will flourish. Informal markets may also deliver milk, regarded as a convenience to some consumers. It's only when consumer willingness to pay for formal product standards increases, or formal markets are seen as more convenient, that the balance will shift. That change is already observed in many settings as disposable incomes increase and modern retailers and supermarkets become preferred outlets of choice.

Policy and investment options for growing formal milk markets are generally well established, which include supporting infrastructure development including electrification for rural chilling plants, human capacity development in processing technology, products, and management, positive regulatory environment to enable effective competition, and financial mechanisms to support small and medium scale enterprises. Organizational models to support these range from cooperatives to producer companies and contract farming and are also either well established or being extensively developed in a number of countries, generally with strong public sector support.

A challenge to formal markets can emerge in the form of market concentration, when large actors are able to influence prices by controlling a large market share, or for example providing the only milk collection services in a given milk shed. A study in South India found that milk prices paid to farmers were significantly higher in villages with three formal milk buyers compared to those with only two buyers (PK Joseph et al). However, the high degree of atomization in milk markets with many mostly small or medium scale actors, generally precludes market concentration except in localized cases. Even in the growing and modern Chinese market, there are over 400 dairy enterprises with greater than 5 million RMB in turnover, although the three largest control some 40% of the market (China Business Insight, 2015). When consumer milk prices in China were rising even while farm prices remained somewhat low, oligopoly practices were suspected. However Dai et al 2014 did detailed analysis of prices and volumes that showed that market power by dairy firms did not increase during mid-2000s, a period accompanied also by increases in numbers of dairy processors, and declines in
numbers of large processors. Cooperatives and other forms of collectives can increase the bargaining power of producers. Vertical integration in supply chains and “super marketization” are seen by some as a threat particularly to small producers, who may be excluded because of lack of volume or inability to meet quality standards. The evidence for these however is not clear. A study showed that small farmers are not being excluded from China’s growing dairy industry. Huang et al 2010 found that because there were competitive markets for milk buyers, and few large players within those, barriers to small farmer participation were minimal. In India smallholders continue to play the dominant formal milk supply role, through both cooperative and private buyers. Reardon and Minton describe a “quiet revolution” in Indian food supply chains, with modern retail sales growing at 49% annually (2011), driven almost entirely by the private sector. However, the growth is from a small base, as the modern retail sector in India recently only comprised 7% of the overall food market. There is however also evidence from studies elsewhere which suggests that fresh foods may be less affected, or at least more gradually affected, by the supermarket revolution. For example, Tschirley et al (2004) among other studies, show that in Kenya, livestock products are among those least likely to be purchased in supermarkets, compared to staples and other dry or processed goods. Consumers often like to milk and other fresh products from generally cheaper local vendors. Avoiding market concentration may be one of the key priorities for dairy policy makers, since it is key to ensure equitable pricing for farmers that stimulates increased and sustained production, and also drives increased demand through lower consumer prices.

Upgrading informal markets
Traditional markets tend to supply low cost fresh produce particularly to poor consumers, and also generally provide a greater proportion of market outlets for smallholder producers. It should be noted that traditional markets generally generate more employment than formal milk markets, because of the labor-intensive nature of their enterprises, which of course is also the basis for their low costs. For example, traditional milk markets in Africa and South Asia were found to employ between 1 and 5 full time people per 100 liters of milk handled daily, at above the minimum wage, far higher than in the case of modern processed milk markets which substitute capital for labor (Omore et al. 2004) From a rural development and employment context therefore, there are important reasons for addressing informal markets.
However, quality and safety issues are clearly important in dairy development, so the challenge is to improve safety and quality in the continuing informal markets, whilst maintaining their key characteristics – meeting consumer preference for traditional products at affordable prices, and supporting poor small-scale farmers and traders. It should be recognized that attempt to “police” informal markets have almost always failed, simply because market forces are too strong. These actions drive informal actors to further hide their activities and to invest less in any modern hygienic equipment that may be at risk of confiscation.

One approach to upgrading informal markets that has been demonstrated in East Africa and in Assam, India is through working directly with informal market actors to increase both their capacity for improved hygiene and food safety, as well as their incentives for doing so. Informal market actors are typically regarded as exploitative middle men and ignored by market development projects, which prefer to work with cooperatives and with modern private sector market players.

One approach used is a “training and certification” strategy which also brings in regulators. Studies found that as expected informal milk market actors had had no formal training in hygiene or generally in business practices, and felt shunned and ignored by development agencies. The approach had three components 1) accreditation of trainers generally in a local NGO or business development services (BDS) provider, b) training of market actors by the BDS provider in handling, hygiene, processing and business skills and 3) close communication with the local regulatory agency to provide some sort of certification or recognition of the trained market actors (Omore and Baker 2011). By providing traders with increased capacity and regulatory incentives, an environment for improved performance can be created. Outcomes included improved profits to traders, better prices for producers, and improved food safety (Lapar et al., 2014).
4. Land, water and other environment related implications of the dairy sector growth

The main environmental issues associated with dairy production concern water and air pollution, biodiversity, and climate change. Water pollution arises from the inappropriate disposal of manure and the application of fertilisers for forage production. Nutrients, principally nitrogen and phosphorous, if emitted in high concentrations, can be a significant component of pollution from agriculture to surface water, groundwater and marine waters, damaging ecosystems through eutrophication and degrading. Water bodies can also be affected by organic effluents and pathogens contained in manure.

Water footprint

In the context of growing water scarcity and food security concerns, water footprints are emerging as an important sustainability indicator in the agriculture and food sectors. Although, water foot printing research is not as mature as that on carbon foot printing available evidence suggests that, at a global level, on a per unit of nutritional value the water footprint of milk compares favourably with other animal source foods (Table 2). These global estimates notwithstanding, that there are many milk producing areas across Asia that are under severe water stress and it is important to reduce the impact of dairy farming on freshwater availability.
Table 2: The global average water footprint of crop and animal products

<table>
<thead>
<tr>
<th>Food item</th>
<th>Water footprint per unit of weight</th>
<th>Water footprint per unit of nutritional value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Green (L/kg)</td>
<td>Blue (L/kg)</td>
</tr>
<tr>
<td></td>
<td>Calories (L/Kcal)</td>
<td>Protein (L/g of protein)</td>
</tr>
<tr>
<td>Vegetables</td>
<td>194</td>
<td>43</td>
</tr>
<tr>
<td>Fruits</td>
<td>726</td>
<td>16</td>
</tr>
<tr>
<td>Milk</td>
<td>863</td>
<td>86</td>
</tr>
<tr>
<td>Cereals</td>
<td>1 232</td>
<td>228</td>
</tr>
<tr>
<td>Oil crops</td>
<td>2 023</td>
<td>220</td>
</tr>
<tr>
<td>Eggs</td>
<td>2 592</td>
<td>244</td>
</tr>
<tr>
<td>Pulses</td>
<td>3 180</td>
<td>141</td>
</tr>
<tr>
<td>Chicken meat</td>
<td>3 545</td>
<td>313</td>
</tr>
<tr>
<td>Pig meat</td>
<td>4 907</td>
<td>459</td>
</tr>
<tr>
<td>Sheep/goat meat</td>
<td>8 253</td>
<td>457</td>
</tr>
<tr>
<td>Bovine meat</td>
<td>14 414</td>
<td>550</td>
</tr>
</tbody>
</table>


A very large part of the water footprint of animal products generally relates to water use for feed (Mekonnen and Hoekstra, 2010). Accordingly, both feed composition and feed conversion efficiency determine the overall water footprint of animal production which in turn depends on production systems and geographical locations. Animals in extensive systems in general have a lower feed conversion efficiency than mixed and industrial system and hence higher water footprint on that account. On the other hand, industrial systems generally use considerably higher concentrate feed (vis-à-vis forages and crop by-products) when compared to mixed and extensive systems which contributes to higher water footprint for industrial systems. So the water footprint varies strongly depending on the production region, feed composition, origin of the feed ingredients and production practices. Some estimates of water footprint for selected countries by broad production systems is shown in Table 2. Although, water footprint estimates for industrial production systems in China and India are not available, experience elsewhere suggests that “the total water footprint is
generally comparable in all three production systems. For dairy products (cheese and milk powder, for example), the water footprint happens to be smallest when derived from a mixed system and a bit larger but comparable when obtained from a grazing or industrial system” (Mekonnen, M. M. & Hoekstra, A.Y. 2012). Considering, however, the intensifying stress on region’s water stress, it is critical to better understand the implications of growing dairy sector on Asia’s water resources and ways and means to better optimize the water footprint by adopting the practices that increase efficiency of water use, reduce irrigation needs, optimise nutrient management and increase feed conversion efficiency.

Table 3: The green, blue and grey water footprint of milk for selected countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Production system</th>
<th>Water footprint per unit of weight (cubic metres/ton)</th>
<th>Green</th>
<th>Blue</th>
<th>Grey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>Grazing</td>
<td>1580</td>
<td>106</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mixed</td>
<td>897</td>
<td>147</td>
<td>213</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>927</td>
<td>145</td>
<td>210</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weighted average</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>Grazing</td>
<td>1185</td>
<td>105</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mixed</td>
<td>863</td>
<td>132</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weighted average</td>
<td>885</td>
<td>130</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>Grazing</td>
<td>572</td>
<td>50</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mixed</td>
<td>431</td>
<td>40</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>500</td>
<td>43</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weighted average</td>
<td>462</td>
<td>41</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>Grazing</td>
<td>1106</td>
<td>69</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mixed</td>
<td>582</td>
<td>59</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>444</td>
<td>61</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weighted average</td>
<td>647</td>
<td>60</td>
<td>99</td>
<td></td>
</tr>
</tbody>
</table>

Manure management
Dairy cow manure is a nutrient-rich fertilizer; when used appropriately it can make significant contributions towards improved crop/fish pond productivity and replacement of chemical fertilizers. However, if not managed carefully, it can become a source of soil and water pollution, biodiversity loss and other economic losses.

Global experiences have shown that land application of livestock manure for the fertilization of crops and grasslands and for improvement and/or maintenance of soil fertility is one of the most appropriate methods of manure utilization. Traditionally pastoral and smallholder mixed systems in Asia have used nutrient and organic matter in manure as input to agriculture or as household fuel. However, with recent ongoing structural changes, scaling up and emergence of large dairy farms in some countries, manure production may exceed local land recycling capacities to the extent that negative environmental impacts related to manure management are likely to grow. Use of available assays for faecal phosphorus and milk urea nitrogen can be used to generate data for the region to assess ‘sustainable animal diets’, manure nutrients and environmental loss. There is a need to better understand appropriate stocking rates and the relationships between the proximity of lands for feed production and manure land spreading and the options available for surplus manure production.

A recent global assessment study on manure management concluded that the value of manure is rather poorly understood by farmers. Almost 40 to 60 percent of the farmers at global level did not make adequate use of dung and almost none of the farmers recycled the nutrients in urine. Main reasons for this situation were poor awareness, labor shortages, and lack of investment opportunities. There is also poor awareness and appreciation of the value of dung among the extension workers and policy makers. While chemical fertilizers have often been heavily subsidized and promoted, the policies on manure management are usually driven by the need to address negative externalities (such as pollution and public health implications) or biogas production potential. Government policies hardly ever reward the use of manure as a nutrient source.

In this context, it is essential to undertake strategic analysis (including policy and institutional analyses, cost effectiveness of manure management practices and preparation of investment guidelines) of manure management practices; (ii) enhanced public and private investment in farm-level data collection, analysis and feedback systems; (iii) scoping, documentation and dissemination of good practices of manure management; (iv) promoting good legislation to prevent discharge of dairy farm manure (including liquids) to surface waters; (v) facilitating
enhanced coordination among scientists from various fields to encourage the integration of animal, soil and plant components; (vi) development of pilot/demonstration farms (incorporating appropriate levels of technology); and (vii) designing and implementing appropriate training courses on nutrient budgets and improved manure management practices.

Greenhouse gases
Dairy farms are a source of greenhouse gas (GHG) emissions, mainly from enteric fermentation (methane) and manure management (methane and nitrous oxide); improving the carbon footprint of the dairy sector is an essential element of sustainable milk production. According to FAO estimates, in 2007, the global dairy sector contributed 4.0 percent to total global anthropogenic GHG emissions. This figure included emissions associated with milk production, processing and transportation, as well as the emissions from meat production from dairy-related culled and fattened animals. Considering the emissions associated with milk production, processing and transportation of milk and milk products only, the overall contribution of global milk production, processing and transportation to total anthropogenic emissions is estimated at 2.7 percent.

Recent studies have pointed out the positive relationship between milk yields and reduction in GHG emissions (Gerber et al. 2011, Powell et al. 2013). This presents a potential win-win opportunity for the region but the relationship between emission intensity and milk yields must be examined within the context of food-feed competition and use of grains in dairy cow rations. While recommending to adopt feeding and management practices with the twin objectives of reducing GHG emissions and improving milk yields, it is important to focus on enhanced use of
local feed resources and balancing dairy cow rations. Overall, the environmental performance of the dairy sector can be affected by technological developments (e.g. improved housing facilities; manure storage, spreading and treatment systems; altering feed composition to improve digestibility of phosphorus and nitrogen using more digestible feed materials or by improving the digestibility of locally-produced feed materials). Further, with anaerobic manure digester technology, farms can recover methane gas for use as renewable energy. The sector has enormous potential to contribute to climate change mitigation. Realizing this potential will require new and extensive initiatives at national and international levels, including: the promotion of research on and development of new mitigation technologies; effective and enhanced means for financing livestock activities; deploying, diffusing and transferring technologies to mitigate GHG emissions; and enhanced capacities to monitor, report and verify emissions from livestock production.

Although, dairy sector is often perceived as an inefficient user of natural resources, the reality is that dairy cows are an efficient converter of human inedible plant material into high-quality milk and when efficiencies of nutrient conversion are calculated on a human-edible basis, dairy clearly adds to the total human food supply (Miller, G. D. & Auestad, N. 2013). Roughage fed ruminants can play an important role as they allow the use of resources that may otherwise not usable for food production (Schader et al. 2015). Recognizing this aspect of dairy production can provide alternative ways of contributing to sustainability and reducing environmental pressures from dairy production.

For example, the ration balancing program initiated by the NDDB of India to improve productivity and reduce feeding cost has already reported considerable reduction in enteric methane emission per kilogram of milk yield in lactating cows and buffaloes. A study conducted to evaluate the efficiency of utilization of dietary protein for milk production in lactating animals showed that on feeding a balanced ration, the average percent dietary protein secreted into milk of the total protein intake increased from 19.2 to 23.5 in lactating animals, indicating significant improvement in efficiency of utilization of dietary protein for milk production. The average N Excretion in lactating animals was 81 percent of the total N intake before ration balancing, which was reduced to 77 percent on feeding a balanced ration. Reduction in N excretion through dung and urine could be an effective method of reducing ammonia and nitrous oxide emission in the environment and improving the efficiency of dietary N utilization for milk production, through balanced feeding. For more information, see Garg, M.R., Sherasia, P.L., Bhandari, B.M., Phondba, B.T., Shelke, S.K. & Makkar, H.P.S. 2013. Effects of feeding nutritionally balanced rations on animal productivity, feed conversion efficiency, feed nitrogen use efficiency, rumen microbial protein supply, parasitic load, immunity and enteric methane emissions of milking animals under field conditions. Animal Feed Science and Technology, 179: 24-35.
Another important aspect of policy related to environmental impact relates to how these are communicated. For example, the carbon footprint of milk is often compared to a number of other beverages without any regard to the nutrient density of the beverages. For example, Semdman et al (2010) argued that it is essential to take into account the nutritional dimensions of various food items when comparing them on the basis of GHG emissions. They presented estimates what they called the Nutrient Density to Climate Impact (NDCI) index for milk, soft drink, orange juice, beer, wine, bottled carbonated water, soy drink, and oat drink. Due to low-nutrient density, the NDCI index was 0 for carbonated water, soft drink, and beer and below 0.1 for red wine and oat drink. The NDCI index was similar for orange juice (0.28) and soy drink (0.25). Due to a very high-nutrient density, the NDCI index for milk was substantially higher (0.54) than for the other beverages which meant in relation to its contribution to nutrition, milk had much lower climate impact than is often perceived.

Overall, it is essential to improve the governance of the sector to ensure that its development is sustainable. As noted above, natural resources such as land, air, water and biodiversity are under pressure and corrective action is needed to encourage the provision of public goods. This will involve addressing policy and market failures and developing and applying appropriate incentives and penalties. Adoption of improved technologies, encouraged by appropriate economic incentives, can improve the environmental performance of the sector.

A key policy focus in this context should be on correcting market distortions and policy failures that encourage environmental degradation. For example, subsidies that directly or indirectly promote overgrazing, land degradation, deforestation, overuse of water or GHG emissions should be reduced or eliminated and market-based rewards and punishment systems that incentivize use of more environmentally friendly practices should be instituted. Payments from public or private sources for ecosystem services can also be an effective means to promote better environmental outcomes, including soil conservation, conservation of landscapes and carbon sequestration (FAO 2009).

A critical question in this context is- what practice change is required to facilitate desired environmental, social and economic outcomes (the triple gain). It is clear that there is “no one size fits all” solution and that there are limitations (e.g., biological) on what can be done in terms of innovation and continuous improvement efforts. Strategies need to be tailored to specific bio-physical and socio-economic features of the prevailing dairy production systems. There are tactical decisions that must be made with regard to the use of feed (an increasingly critical variable) and nutrients. Recommendations on what to feed
dairy cows have large impacts on profitability, manure chemistry and environmental outcomes. Feed supplements may need to be subsidized and made available during periods of feed shortages (drought), and manure land spreading may need to be restricted based on topographic features and weather.

Finally, addressing environmental issues would require provision of on-farm technical assistance and extension services to farmers. The aim should be to achieve environmental results at least cost to individual farmers. In some countries regulations on large producers would be necessary and such regulations must become an integral part of dairy development policies and strategies while at the same time being embedded in the overall environmental strategies at the country level. Equally important would be to undertake and promote research and development on adaptation to ongoing climatic changes; for example, identification of animal breeds and feed crops that perform well in future environments of higher temperatures and water deprivation. The long-term productivity and resilience of cross-bred animals in the environment in which they are reared should be the basis for their selection for future use.

5. Summary and conclusions

The discussion in the paper suggests indicates that milk yields are generally low in many Asian countries by global standards, and at least with the data available, may not be improving significantly. This is in spite of the evidence of substantial exploitable yield gaps and gradual but continual advances in the breeds developed for tropical low-input environment, in addition to improved feeds and animal health. Importantly, variation in yields may be large even in similar setting among similar breeds, suggesting opportunities for closing the yield gaps with targeted interventions. Farm sizes are found to be generally small, with little evidence of growing significantly except in some cases. This is a common phenomenon in settings where the opportunity costs of labor are relatively low, which leads to little if any economies of scale in production. Finally, costs of production are relatively low in Asia compared to global comparisons, and again, and are not seen to be related to scale.

Yields levels and farm size are often farmer choices in themselves, and are determined by relative factor values (particularly land and labor), access to markets and technology. A study by Baltenweck et al (2003) indeed found that the land/labor ratio alone was the main determinant of various forms of
intensification of crop livestock system across 15 counties globally. Note that land and labour values may reflect access to markets and technology. Unit costs on the other hand, may be relatively similar in contracting production systems, both low and high input. The policy and investment result of this evidence is that no single model of dairy production can be considered as superior to others, and is very likely to be specific to local resource and market contexts. Efforts to arbitrarily increase scale of farms should be limited to places where labor costs are increasing rapidly, and although where scale comparisons are most useful are within any given production and market environment. In general investment should be to provide improved access to extension, technology and markets, which all assist farmers to make the best informed choices as to optimal production strategies that match their resources, including which technologies to use and optimal herd size.

Overall, the evidence presented above does point to strong competitiveness of dairy in Asia, in addition to opportunities for growth at the level of production efficiency. However, the policy makers must understand that milk and milk products are high value commodities with relatively high income and price elasticities. The demand for such products responds more rapidly as incomes increase. But, elastic demand also has a down side. If the price goes up, consumption can choke off. Thus, it is important that the cost of dairy production in the region be constantly reduced. Globalization and resultant competitive pressures reinforce the need for cost reduction. The region must ensure production increases without putting undue pressure on prices. That means advances in disease control, in feeding efficiency, in breeding, and in management. There has been a tendency to underinvest in research and extension for that research to be excessively concentrated in disease control and breeding at the expense of nutrition and management. Animal husbandry research and extension needs to be associated with the full range of agricultural research so that synergies between feed production and feeding of animals can be developed. Considering the enhanced role of private sector research in recent times, it is also essential to develop synergies between public and private sector research and to ensure trade policies that eliminate dumping and unfair competition and contribute to positive local development outcomes.

Projections to 2050 for dairy supply in demand show clearly that strong demand growth will continue to provide opportunities for the region. However East and Southeast Asia will continue to be net importers, while South Asia is expected to
become a significant exporter. Policy makers should resist protectionist tendencies in those countries aiming to develop their national dairy industry and build ties better dairy trade ties between East and South Asia. Trade liberalization is likely to continue and will provide incentives to evolve due to pro-competitive effects to take up new technology and practices. This will be facilitated by increased opportunity costs of labor as economies development, further shifting factor incentives to higher productivity strategies.

While these trade opportunities will grow, dairy markets will remain mostly national and local and should be the major area of attention. Price differences between countries are unlikely to have significant impacts locally. Decision makers should pay particular attention to mitigating market concentration, while at the same time supporting infrastructure and capacity development, and providing a supportive financial and regulatory environment for SME.

At the same time, it is clear that small actors are likely to continue to play important roles in linking farmers to markets. Policy interventions should avoid equating the ‘private sector’ with only large-scale industry players, but recognize and leverage the role of the numerous small market actors. Similarly, market forces are likely to ensure that in some countries in South Asia large informal milk markets will continue to hold large share of the market. Development investment and regulatory policy should seek to upgrade such markets. Any pro-poor livestock policy needs to proactively engage with small-scale actors in terms of capacity development in terms of product handling for quality and safety, as well as business skills, adoption of standards, organization and collective action to upgrade value chains.

Finally, it is important to recognize that climate change, water scarcity, land degradation and increased resource competition for food, feed and fuel production pose major additional challenges for the sector in the long run. The environmental and natural resource implications of dairy sector growth have recently come under close scrutiny and the debate on climate change has been particularly passionate. At the global level, the sector is a large user of agricultural land, through grazing and the use of feed crops, and plays a major role in climate change, management of land and water, and biodiversity. The natural resources that sustain agriculture, such as land and water, are becoming scarcer and are increasingly threatened by degradation and climate change. Despite that fact that, at a global level, on a per unit of nutritional value the water foot print of milk compares favourably with other animal source foods, there are many milk producing areas across Asia that are under severe water stress and it is critical to
better understand the implications of growing dairy sector on Asia’s water resources and ways and means to better optimize the water footprint. Another important aspect of policy related to environmental impact relates to how these are communicated. For example, the carbon footprint of milk is often compared to other food items without any regard to their nutrient density. This only presents half the picture of the environmental impact. Similarly, dairy sector is often perceived as an inefficient user of natural resources, while the reality is that dairy cows are an efficient converter of human inedible plant material into high-quality milk and when efficiencies of nutrient conversion are calculated on a human-edible basis, dairy clearly adds to the total human food supply. Recognizing these aspects of dairy production can provide alternative ways of contributing to sustainability and reducing environmental pressures from dairy production. Nevertheless, there are areas where the environmental impact of a growing dairy industry can be significantly reduced without sacrificing social and economic gains. As a preliminary step in the direction of a sustainable dairy sector, it is important to first understand the biophysical, social and economic factors that lead to undesirable environmental outcomes, and the actions necessary to produce the positive, desired outcomes. Strategies need to be tailored to specific bio-physical and socio-economic features of the prevailing dairy production systems. This would require long-term investment and multi-stakeholder coordinated action to stimulate innovations towards sustainability.
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