BETTER FEED FOR HIGHER LIVESTOCK GROWTH

VI. Better feed for higher livestock growth

According to government data, Pakistan's population of dairy animals (buffaloes, cows, goats, and sheep) was 211.5 million in FY22[6]. This is just shy of Pakistan's human population but mostly growing faster at three to four percent per annum for buffaloes and cows and 2.7 percent for goats over the past fifteen years. With ninety-seven million buffaloes and cows in the country in FY22, beef dominated meat production at 2.5 million tons; with eighty-two million goats (much smaller animals), the mutton production was 0.8 million tons. The total milk output available for human consumption was 53 million tons—among the highest in the world. These milk- and meat-producing animals are challenged by Pakistan's poultry population both in number (1.7 billion birds), output (two million tons of chicken meat and 22.5 billion eggs) and growth rate (a blistering 9.5 percent per annum rise in the flock over the past fifteen years). Even though many industry stakeholders question government data regarding animals in Pakistan, these numbers definitely indicate the momentous challenge of providing sufficient food to Pakistan's human population and sufficient feed to Pakistan's animal population.

Pakistan's poultry sector has shifted to a mostly commercial industry over the past couple of decades. Over ninety-five percent of Pakistan's poultry is grown on commercial farms with modern genetic material and modern feed systems. The remaining poultry is under the husbandry of rural families. By contrast, about eighty percent of Pakistan's dairy animals are with small farm families. A livestock census has not been held since 2006. And multiple floods and other natural calamities having hit Pakistan since then. So, industry experts express concerns that the animal population may be less than the government data cited above. In this situation, a useful outcome from the 2006 census is the herd distribution. Nearly eighty percent of the cows and buffaloes at that time were in herds of up to fifteen animals. These animals are mostly of local breeds held by an estimated 8 million farm families. The vast majority of these families holds three to six animals averaging four to seven liters daily milk yield mainly to fulfil their own family needs while a portion of these farm families sell some of their milk to the market. Among a good part of the subsistence-level dairy farming families, there is scarce inclination towards the potential of modern livestock[7]. This is why the concept of 'idle dairy capacity' is often mentioned about them.

A second category is of mid-sized dairy farms typically with a herd of twenty-five to a hundred animals each, including in peri-urban areas. Again, the traditional breeds dominate these farms with some imported animals cast off from Pakistan's handful of 'corporate' dairy farms. Using the average daily milk yield of the animals as a proxy for performance, these mid-sized farms are estimated to yield fifteen to twenty liters per day per animal which may hit twenty-five liters at peak lactation in some cases. Lastly, there are less than twenty 'corporate' dairy farms in Pakistan which typically carry 2,000 to 8,000 genetically proven imported breeds. These farms attain twenty-five to thirty-five liters daily milk yield

6 Government of Pakistan (2022). Pakistan Economic Survey 2022-23, Tables 2.14, 2.15, and 2.24

7 This is section is based on Shahzad, A. (2022). The need for national livestock surveillance in Pakistan, Muhammad Aamir Shahzad, Journal of Dairy Research, Volume 89, Issue 1, February 2022, pp. 13 – 18 (published online by Cambridge University Press: 2022).

per animal. They employ modern livestock management practices and technologies with precision feeding delivered using appropriate feed machinery, feeds, and practices.

Pakistan's feed challenge is to deliver an adequate and reasonably priced supply of quality feed inputs for these poultry and dairy animals (targeted in this note) while motivating family farms to move in the direction of improved feeds for higher animal productivity and better animal health.

Feed 101

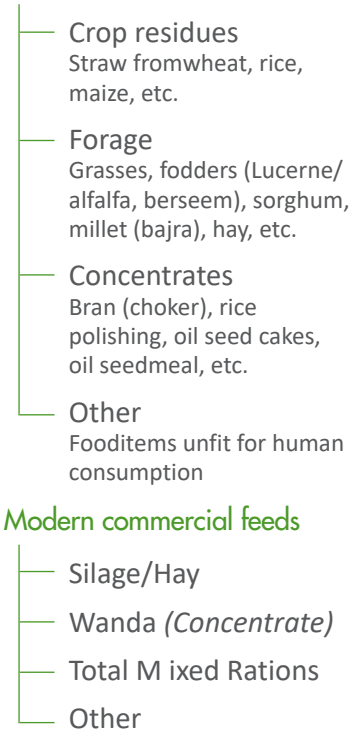
Feed for animals is like food for humans. The animals can be fed 'whatever is available' but, for specific commercial outcomes—such as greater meat output and higher milk productivity—the composition of feed must be based on the science underpinning the conversion of feed into energy. This typically involves giving the animal a feed mix delivering carbohydrates, protein, fats, vitamins, and minerals, etc. (and, of course, water), in optimal measure. As in food for humans, sources of carbohydrates (typically, wheat and rice—*roti chawal) are cheaper than sources of protein. Fats have a higher energy content than both* carbohydrates and proteins and so are the most expensive used sparingly in feed[8].

Dairy feed Pakistan's feed for dairy animals is mostly in the 'whatever is available' camp. The dominant sources of feed are conventional: crop residues and forage.

Crop residues: The crop residues available for animal feed are primarily the stems and leaves (or straw) that remain after the grain is removed from field crops such as wheat, rice, maize, etc. When the proverbial wheat is separated from the chaff, the chaff is typically found to weigh the same or more than the grain depending on the crop. So, a small farmer's wheat crop yield of thirty maunds of wheat grain per acre (1.2 tons per acre) also yields 1.5 times this weight in wheat straw.

In a modern farming operation, this organic matter is chopped and ploughed back into the soil to increase the proportion of nutrients for the next crop. But this is not commonly practiced by small farmers in Pakistan. The straw is either kept for the small farmer's own animals or sold for additional revenue to the market that serves animal feed, the pulp and paper industry, and other products. In this way wheat, Pakistan's dominant crop and staple food, produces food for humans plus feed for animals.

Figure 32: Dairy feed in Pakistan



8 This section is based on Abbas, R. et al. A Study on Feed Stuffs Role in Enhancing the Productivity of Milch Animals in Pakistan- Existing Scenario and Future Prospect, Global Veterinaria 14(1): 23-33, 2015

Crop residues are considered low quality feed mainly because they are low in protein and minerals though high in fiber. But they are less digestible. Wheat straw is by far the largest component of crop residue for feed followed by maize and rice straw as well as rice husk (shell in which grains grow—removed before processing).

Forage includes various types of grasses and fodders as well as sugarcane tops, tree leaves, etc. Generally speaking, grass is just grass. But among specialized grasses, Rhodes grass has been cultivated in Pakistan for local consumption by animals as well as export. The common fodders cultivated even by Pakistan's small farmers for their own animals' feed are Barseem and lucerne (alfalfa) which typically grow in the winter. Forage is easily digestible but high in moisture (the dry matter is what counts for feed, not the moisture). Hay is dried fodder and, since medieval times, small farmers have typically made hay only while the sun shines. Sorghum (*Jowar) is* also grown locally in summer often with imported seed.

Concentrates are often low in fiber but high in protein and highly digestible by animals. They are often the expensive part of feed used in small quantities and are mixes of multiple ingredients. These ingredients are typically by-products of other commercial activities and generally have informal markets which serve farmers and other users of these items. These ingredients can be of plant origin or animal origin:

- The common plant-origin ingredients in Pakistan are by-products of grains—rice polishings, maize bran, wheat or rice bran (choker), molasses (sheera), etc.—and by-products of the extraction of oil from oilseeds. The feed by-products from mechanical extraction of oil from various types of seeds are called oilseed cakes and the by-products from solvent-based extraction of oil are called oil meals (low in protein but high in residual fat). Oilseed cakes (khal) from cotton seed (banola) are quite common. Oilseeds imported for production of edible oil (e.g., soybean seed, canola seed, etc.) are sources of soybean seed cakes, canola seed cakes, soybean meal (figure 33), etc.
- Animal-origin ingredients (blood meal, fish meal, bone meal, meat meal and feather meal) are good sources of protein but are used less now given the prospect of disease transfer through them. Plant-origin concentrates are more widely available in rural areas than animal-origin concentrates and are also cheaper.

Other Feed affordability and supply constraints mean that animals are also fed pieces of dried bread (pieces of *naan or roti) and,* mainly at urban/peri-urban farms, confectionary waste as well. Damaged wheat that is discarded from the food industry as unfit for human consumption is also fed to animals. These sources of feed can have higher levels of aflatoxins (a family of carcinogenic fungus) and the levels are also high in seed cakes especially Cotton Seed Cake.

Figure 33: Soybean meal, oil and soybeans

Source: Feedpedia

Supply dynamics of conventional feed

As with food for humans, no single animal feed source is sufficient to meet all the nutritional needs of animals. Most commonly on Pakistan's small farms, animals are fed a mixture of crop residues, green fodder, and concentrates. The exact mix/requirement depends on multiple factors: the prevailing temperatures and environment, the phase that the animal is in (dry phase, lactation phase, weaning, etc.). The most commonly used additives for animal feed which are also sources of protein for animals on smallholder farms are cottonseed cake (*banola khal) and* wheat or rice bran (*choker).*

Figure 34: Traditional storage of wheat straw

Source: Daily Dawn (Sahiwal, Pakistan).

Fodder is grown on small patches even by small farmers to serve their animals and to sell in local markets. Pakistan's growers have faced a fodder shortage for decades particularly off-season: June-July and December-January. Therefore, animal feed in these periods is mostly in the form of crop residues. Farmers usually store crop residues to feed their animals because of easier storability, especially for periods of fodder shortage. As figure 34, these roughages are stored in piles (*dhar) in an open field layered on top* with a paste of mud and chaff to protect it from rain and other environmental factors. Dry crop residues are also stored as bundles and are available for purchase locally.

The dominant conventional sources of feed have a high moisture content while the actual feed available to the animal is measured in terms of Dry Matter Intake (DMI). With periodic shortages, the difficulty in storing and transporting these traditional sources of feed in large quantities while maintaining quality is a reason why modern commercial feeds are becoming more popular among growers who can afford them.

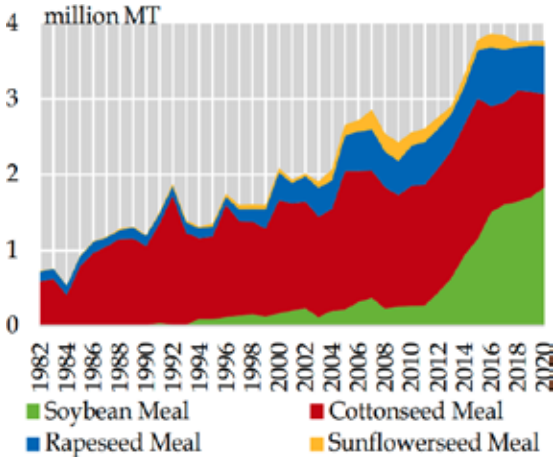
Modern commercial feeds to protect animal health and boost animal productivity, balanced feed typically includes the requisite proportions of carbohydrates, protein, fats, vitamins, and minerals. The average dry matter intake requirement of an animal is in the range of three percent of its body weight[9].

9 Abbas, R. et al (2015)

Silage is primarily based on maize (corn) in Pakistan. In simple terms, silage is the entire maize plant (including the corn and the cob) harvested, chopped up, packed into bales or dumped in silage bunkers, and allowed to ferment without oxygen. In this form, the maize can be stored for long periods which improves the availability of green fodder during times of fodder shortage. If suitable anaerobic conditions are not provided, then proper acidic conditions will not develop which is crucial for the fermentation process to preserve the quality of fodder and to avoid spoilage. Silage is yet to gain popularity among smallholder farmers and its use is still limited to medium- to large-scale farms.

Wanda or compound feed is another increasingly common source of protein and other nutrient supplements for a balanced diet. A typical compound feed consists of cereal grains (like maize), choker/ bran, soybean meal, canola meal, sunflower meal, rapeseed meal, rice polishing, minerals, vitamins, molasses, and bypass fats.

Figure 35: Rising use of oil seed meal in Pakistan



Source: State Bank of Pakistan

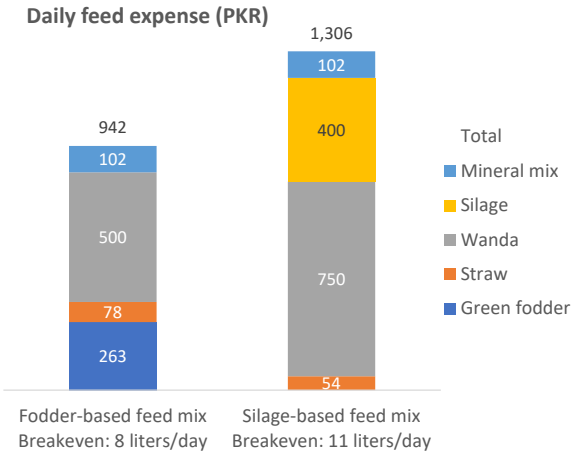
Total mixed rations (TMR) refer to dairy feeding systems that are a combination of roughages (like wheat straw), fodder, maize, bran, soybean meal, canola meal, sunflower meal, rapeseed/mustard meal, rice polishing, minerals, vitamins, molasses, and bypass fats. Figure 35 shows the rising use of oilseed meal in Pakistan. The combination of TMR also depends on environmental factors and the phase that the dairy animal is in. TMRs are mostly used in what are called 'Corporate/Mega Dairy Farms' in Pakistan. These farms have the dairy farm design and equipment (e.g., TMR mixers) that allows for the provision of a balanced feed. A corporate dairy farm also makes the provision of TMRs relatively less expensive with economies of scale.

Poultry feed is typically a combination of maize, soybean meal, canola meal, and other ingredients. Maize is the dominant component accounting for some forty-five percent of poultry feed. Soybean meal is next at about a quarter of feed as a source of protein. The rest are canola meal, rapeseed meal, and animal protein feed, rice polishing (the finely ground material obtained in polishing the rice kernels after the husk and the bran have been removed), etc. So, fluctuations in maize and soybean prices impact the price of feed.

How the economics of feed impacts the farmer's choice of feed

For larger dairy farms, animal feed costs account for roughly seventy percent of the total cost of producing milk. These dairy farms incur the capital expenditure of building proper housing for animals, milking machines, TMR mixers, etc., while salaries, electricity, feed, and animal disease are the major operational costs. But, at the smallholder level, animal feed is considered to be the only expense as members of the household normally handle the animals and extra help is not hired for the animal's upkeep. Moreover, the animals are kept in or near the household and no major expenditures are incurred for their shelter or general maintenance. Occasional veterinary services can incur some expense. Therefore, it is important to understand how the economics of feed impacts the farmer's choice of feed.

Figure 36: Better feed requires better genes



Calculations based on dry matter intake.

The general rule of thumb in the dairy sector is that the average animal's dry matter Intake is in the range of three percent of the animal's own weight. This means that a five-hundred-kilogram dairy animal should be fed about fifteen kilograms of dry matter daily. This dry matter content differs from one feed type to another. For example, green fodder usually has between eighty and ninety percent moisture content which means it has sparse amounts of dry matter. By contrast, the moisture levels in silage are a little lower (between sixty and seventy percent) while straw and other crop residues have between twelve and twenty percent moisture levels. Therefore, the gross weight of feed required daily is much higher than the range of fifteen kilograms mentioned above. Another rule of thumb is that the kilograms of concentrate mix required in dairy feed are generally half of the average milk produced per day. For example, a dairy animal producing ten liters per day will be fed a total of three to five kilograms of concentrate throughout the day[10].

A five-hundred-kilogram animal will be fed a combination of green fodder, crop residue, and concentrate to fulfill the animal's dietary requirements. At prices prevailing at the time of writing, this feed mix is estimated to cost close to 950 rupees per day. Therefore, at a farm-gate milk price of Rs. 120 per liter, the breakeven production is at around eight liters per day. The average milk yield of buffaloes owned by 'part- commercial' growers is around ten liters per day which means the farmer's profits are only two liters per day. However, many smallholder dairy farmers do not sell all of the milk produced and keep a portion of the milk for household consumption. So, a smallholder dairy farmer would barely be breakeven with this feed mix. The result is that a number of smallholder farmers reduce their feed expenditure by supplementing the feed requirements through other cheaper sources of feed like grazing where possible

10 Dairy hub training booklet, Balanced Ration.

and adding kitchen scraps like fruit and vegetable peels and residues, dried *roti, bakery leftovers, etc.*[11] Providing a balanced feed is only economical for farmers if they obtain a higher yield. Of course, this stylized calculation does not account for the dry periods in the milking cycle of the dairy animal so the breakeven production is effectively much higher than eight liters.

The animal needs to have the genetic potential for higher milk productivity, otherwise the expenditure for improving animal feed will not be compensated. Figure 35 shows the farmer's economics for replacing green fodder with silage which is more expensive (but with less moisture than fresh fodder) for a higher yielding dairy animal. The increased spending on quality feed is mainly justified by a higher milk productivity genetic potential.

Typically, the sources of better genetic potential in Pakistan's dairy sector are the dairy animals imported by the 'Corporate/Mega' dairy farms and some mid-sized commercial farms. Some of these animals find their way to other growers as well. The practice of artificial insemination can improve the genetic potential of domestic breeds. In simple terms, this is the process of introducing the semen of better breeds into female dairy animals of local breeds. The result is off-spring (next generation) with characteristics of better breeds. Artificial insemination is already in use in Pakistan but requires significant expansion to improve the genetic composition of the national dairy herd.

State of Pakistan's feed industry

Poultry Pakistan's poultry feed industry produced 6.4 million tons of feed worth Rs. 448 billion in FY21[12]. This feed is produced from the key inputs of maize, soybean meal, canola meal, and other agricultural products/by-products. Covid-19 hit poultry consumption hard causing a significant reduction in poultry consumption. This impacted the feed industry as well forcing it to operate at 45 percent of its capacity of 13.3 million tons in FY21. That year, the feed industry's production was about a third lower than its peak production of 9.8 million tons in FY17. The poultry feed industry is fragmented with about 350 feed mills scattered mostly in Punjab's maize belt (broadly, the districts between Lahore and Multan).

Dairy Pakistan's dairy feed industry is pre-dominantly in the informal sector and specific information about each component is not easily available. The different types of fodder are typically grown on an estimated 6 million acres producing about 55 million tons of fodder in FY19[13]. A number of small dairy farmers grow their own fodder on a patch of their land and rely on stored hay, straw and other crop residues to feed during periods of fresh fodder shortage. Excess fodder and crop residues are also sold and the market for these products is mostly in the informal sector. Concentrates of varying quality and compositions are manufactured in compound feed processing mills and are available for purchase in the local market. The ingredients depend on the exact composition, although a large amount of grains,

11 Handbook of Dairy Nutrition Pakistan, published by American Soybean Association, 2009
12 This section is based on PACRA (2022). Poultry Feed Sector Study, January 2022.
13 Government of Punjab (2019). Ayub Agricultural Research Institute, Faisalabad, website: https://aari.punjab.gov.pk/fodder_cropvarities

residues from grain processing (such as bran and polishing), oilseed cake and meal are used to manufacture concentrates. Credible reports that describe the concentrate industry are difficult to finds.

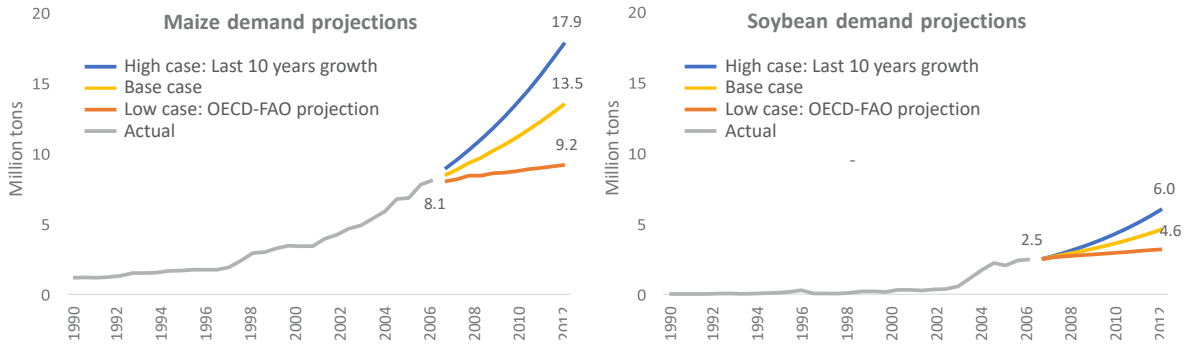
Can Pakistan produce the feed required in the coming decade?

The demand for livestock products, particularly poultry, has continued to rise over the past decade or so despite the fluctuations in Pakistan's economic growth from year to year. Growth is expected in the rest of this decade as well. The OECD expects that India and Pakistan, important milk producers, will contribute more than half of the growth in world milk production over the next ten years and will account for more than 30% of world production in 2030[14].

The number of poultry birds in Pakistan has risen at 9.1 percent per annum in the decade ending in FY21. The poultry feed produced for these birds was 6.4 million tons. This feed output was made possible by a 9.2 percent annual growth in Pakistan's maize output in the same decade. Poultry feed demand for maize accounted for seventy percent of total maize production according to poultry industry experts. These experts see maize demand from the poultry feed industry continuing to grow similarly over the next decade. Along with this poultry feed demand for maize, industry experts estimate that the proportion of the maize output going to dairy feed products (silage, wanda, etc.) is about ten percent. This maize demand for dairy feed can be assumed to grow at the rate at which the number of cows and buffaloes has been rising over the past decade—about 3.5 percent per annum. Figure 36 shows a high case for maize demand projection using the projected growth in two components of maize demand while keeping other components constant (maize for production of industrial starches and for human consumption).

By contrast, the OECD-FAO Agricultural Outlook 2022 does not project this breakneck growth in maize consumption in the decade ending FY31. The OECD-FAO projections show Pakistan's maize demand rising at 2.2 percent per annum between FY21 and FY31. This can be considered a low case for maize demand. Figure 37 shows the high case, the low case, and the average of these two projections as a base case.

Figure 37: Maize demand projections



Source: Author calculations (Economic Survey of Pakistan, OECD-FAO)

14 OECD/FAO (2021). OECD-FAO Agricultural Outlook OECD Agricultural Statistics, http://dx.doi.org/10.1787/agr-outl-data-en

Maize Pakistan has had a remarkable maize production journey since 2001 when the government introduced a framework for the import of hybrid seeds. Maize yields have tripled since that time while the acreage under maize has risen by fifty percent. The result is a 444 percent increase in maize production to about nine million tons in FY21 and rising. Looking back at the past two decades, the main reason why the increase in maize production was possible was the rising adoption of hybrid maize seeds (primarily across the Punjab where nearly all of the hybrid maize is grown). Even if we assume non-feed demand for maize to remain constant between FY21 and FY31, these basic calculations project the maize demand to nearly double from 8.9 million tons in FY21 to 17.9 million tons in FY31. How can this increase be achieved?

Soybean meal Pakistan imported 2.5 million tons of soybean worth US$ 1.4 billion in FY21 which was a notable component of national imports—three percent of the total import bill for the year[15]. About two million tons of soybean meal was produced as a by-product of the extraction of oil from this imported soybean by the edible oil industry. Soybean has been imported into Pakistan since the 1980s. Figure 37 shows that soybean meal consumption has risen sharply over the past decade as a high case, the OECD-FAO 2022 projection as a low case, and their average as a base case. This is driven primarily by the poultry feed industry's demand for soybean meal. Pakistan's local soybean output is a few thousand tons a year.

These numbers allow an estimate of the foreign exchange impact of maize and soybean imports in the coming decade. Using the projected base case and the last three years' average maize price (US$260 per ton), these projections indicate that Pakistan's import bill for maize would be US$ 1.2 billion in FY31. Similarly, using the base case projection of volume of soybean and the last three years' average soybean price (US$500 per ton), the import bill for soybean—only driven by poultry feed demand—would rise to an estimated US$ 2.3 billion in FY31. The local cultivation of these crops can take place with imported hybrid seed costing a fraction of the large bills for importing the crops themselves.

How can domestic production of feed rise to meet demand?

The main prospect for increasing maize output further from the same acreage is the adoption of genetically modified hybrid maize. Industry experts expect GMO hybrid maize to increase output by twenty to thirty percent from the same acreage. And this could take the domestic maize output halfway to the base case maize demand projected for FY31. But Pakistan is yet to make up its mind about GMO products. This is an issue that has caused significant difficulty for Pakistan's feed industry. In October 2022, the federal government's Department of Plant Protection (DPP) started requiring that soybean importers present an import license from the Ministry of Climate Change (MOCC) as a condition for releasing soybean shipments (even those on the high seas enroute to Pakistan). The MOCC had no system for receiving and/or processing import licenses for soybeans destined for food, feed, or

15 Special Section: Pakistan's Rising Palm & Soybean Imports: Understanding the Drivers and Challenges to Domestic Oilseed Production, SBP quarterly report for 1st quarter FY22.

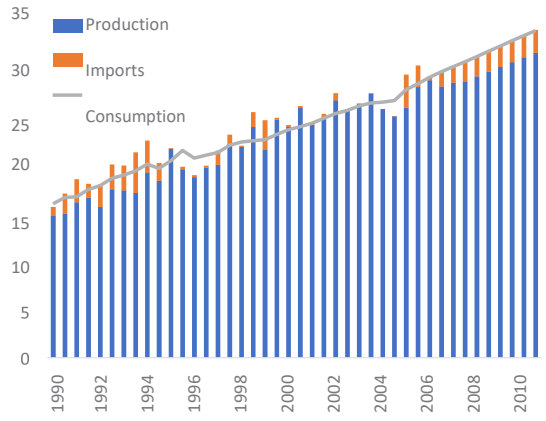
processing[16]. In the seven prior years, DPP had approved and cleared nearly 14 million tons of GMO soybean imports, none of which included an MOCC license. By the time this was resolved, poultry prices had risen and importers had suffered. The GMO seed issue must be addressed to expand Pakistan's maize and soybean output.

The remaining increase in maize and soybean output would have to come from increase in the area under maize and import substitution of soybean. This can only happen at the expense of other crops. Maize has two crops each year in Punjab: its summer *(Kharif)* planting is bigger than its winter *(Rabi)* planting. Soybean and other oil seeds are all sown in the winter. The summer maize crop has already taken away acreage from other kharif crops, including cotton. So, further increase in acreage during the summer would be difficult. By contrast, the winter maize crop and oilseeds compete mainly with wheat. The prospect of maize replacing more acreage under wheat can only be realized if wheat yields rise.

Wheat is an important crop from the animal feed point of view as well in Pakistan. An estimated eighty percent of Pakistan's farms grow wheat during the winter and keep a third of it (plus the corresponding straw) for the use of their families and animals during the rest of the year. The remaining wheat output is either purchased by provincial governments or by flour millers both aiming to deliver flour to the urban population. The most likely path towards convincing more smallholder farmers holding three acres to grow maize or soybean in the winter is by providing them with higher quality wheat seed than they currently have access to. The current average wheat yield of thirty maunds (1.2 tons) per acre means this farmer's total wheat output is 3.6 tons. But Pakistan's progressive farmers easily take forty-five maunds (1.8 tons) from each acre of wheat. If a smallholder can get the same yield of wheat from each acre, i.e. 3.6 tons from just two acres, then it is possible for the farmer to grow maize or soybean on one of the three acres. But this is not the only reason for increasing wheat yields.

The OECD-FAO Agriculture Outlook 2022 projects growth in wheat consumption in FY21-31 which is generally congruent with the wheat consumption growth witnessed in the past couple of decades (figure 38). So, these projections can be used as a base case. The projection assumes business-as-usual for the wheat crop with the same seed and other inputs being used in the coming decade as well. This shows Pakistan's wheat demand reaching thirty-three million tons in FY31 while production only reaches 30.8 million tons—an import of over two million tons!

Figure 38: Wheat projections for Pakistan



Source: OECD-FAO

Pakistan's annual wheat import is projected at two million tons in this decade—a consistent burden on Pakistan's foreign exchange reserves. Using the international wheat price for the last ten years (US$ 250 per ton), Pakistan's average wheat import bill can

16 USDA (2023). *Oilseed and Products Update – Pakistan,* Report PK2023-004, page 2

be estimated at half-a-billion dollars each year. But taking the elevated international wheat price average of the last three years (US$ 337 per ton), this bill rises to US$ 700 million per year. And the imports come without straw to feed dairy animals. Overall, Pakistan *must increase its wheat yields as soon as* possible—not just for food but also for feed.

Feed quality

A major concern in milk quality is the occurrence of aflatoxins (carcinogenic toxins). A 2020 study conducted in Punjab on over 240 samples (of milk and animal feed each) revealed that over 53% of raw milk samples from dairy farms exceeded the maximum residue limit for aflatoxin M1 set by the US Food and Drug Administration (FDA)[17]. Moreover, 95% of feed samples surpassed the FDA limit for aflatoxin B1. The results indicate the prevalence of feed of poor quality and its impact on the quality of milk. The study also found that higher-priced feed correlated with lower levels of M1 and B1 aflatoxin contamination. Farmers sometimes offer bread pieces and other kitchen and bakery waste to animals, which can contain high levels of aflatoxin contamination. Another study indicated that animals fed with bread pieces produced milk with higher aflatoxin levels. Meat quality is less impacted by feed quality but meet yield is reduced by low quality feed. Unfortunately, thermal processing methods like pasteurization and UHT treatments are ineffective in reducing aflatoxin effects due to their stability at high temperatures. Oil Seed cakes are also prone to fungal growth, underscoring the importance of using high-quality concentrates and feed to maintain animal health and ensure the quality of dairy products. Therefore, improving the quality of feed is critical for quality livestock outputs from a food safety perspective.

Conclusions and policy priorities

Pakistan's livestock endowment is critical to national food security. This paper shows that Pakistan is looking at **not only a rising food insecurity in the coming decade but also a rising feed insecurity.** Since feed typically accounts for about seventy percent of the cost of producing livestock products, the rise in feed insecurity means a lower quality and quantity of livestock products which means **higher prices of livestock products.** Further dependence on imported ingredients of feed is also a source of insecurity.

The primary policy goal for feed must be: adequate and reliable feed supply at affordable prices. But the outstanding rise in maize production over the past two decades (driven by the adoption of hybrid maize seed) is reaching its limits. The import of soybean is at three percent of Pakistan's import bill and rising. Wheat imports are projected to rise. Foreign exchange is already scarce.

Some eighty percent of Pakistan's dairy animals are with small farm families. So, what is the way forward? It is well known that higher animal yields require better feed. But this paper has tried to demonstrate

17 Akbar, Naveed, et al. Assessment of Aflatoxin in Milk and Feed Samples and Impact of Seasonal Variations in the Punjab, Pakistan. Food Science & Nutrition, 14 Apr. 2020, www.ncbi.nlm.nih.gov/pmc/articles/PMC7300088/

that, in a developing country like Pakistan where smallholder farmers have extremely limited resources, the opposite is true as well. For better dairy feed to be financially feasible for smallholder farmers, higher dairy yields are required and for that improved genetic potential is important.

The good news is that Pakistan's poultry industry has already cracked this chicken-and-egg problem through the consistent introduction of higher and higher genetic material in Pakistan's poultry flock. Yields have consistently risen which means that the price at which the poultry farm breaks even has fallen. The result is a decrease in the price of poultry products *in real terms.* But this jump was possible because over ninety-five percent of Pakistan's poultry is raised on commercial farms—not on family farms. This experience shows that the poor-feed-low-productivity nexus can be addressed through the introduction of better genetic material in Pakistan's dairy herd. But for this, a major shift is required on the demand side of the dairy feed sector. In addition to the 'Corporate Dairy Farms, Pakistan needs to encourage the expansion and increase in sophistication of commercial dairy farming particularly medium-sized dairy farms by facilitating financing as well as the adoption of new technologies through tax incentives.

There is also a way forward for smallholder farms. The **expansion of artificial insemination** is a route to achieving higher genetic composition in Pakistan's dairy herd. Smallholder farm families need to be provided with the financial resources, know-how, and technical services to allow such improvement of their breeds. This will create demand for higher quality feed and lead to higher dairy productivity. This shift should gradually help reduce the proportion of feed of low quality that is fed to dairy animals.

On the feed supply side, **the future of wheat, maize, and soybean must be guided in tandem.** The projections for these key components of feed indicate that shortages of maize, soybean, and wheat can be added to Pakistan's fodder shortage. The estimates show that, if business as usual prevails, Pakistan could be looking at an incremental $4.2 billion of imports related to feed in FY31. To avoid further imports of maize especially soybean, Pakistan must quickly **remove the broader challenges to seed improvement and resolve the debate on genetically modified crops.** Pakistan's institutional framework for seed must instill sufficient confidence in international seed players to **invest in local production of hybrid seed**—which will remove the need for seed imports as well. With that, the way to substitute soybean imports is to displace wheat since both are sown in the winter. Similarly, the ways to increase Pakistan's maize production are the introduction of genetically modified hybrid maize and expanding the area under maize. The latter is most feasible in the winter crop which, once again, requires displacement of area under wheat. Therefore, **to increase maize and soybean output, wheat yields have to rise** to give farmers the same income from less acreage. These measures can put Pakistan's feed sector on a sustainable footing to serve the coming growth in demand for food and feed.