


China's Dairy Chains,

Towards qualities for the future

Hans Schiere
Xiaoyong Zhang
Kees De Koning
Huib Hengsdijk

September 2007

WAGENINGEN UR
For quality of life

Disclaimer

This report is based on observations from literature, field visits, meetings, seminars and workshops. It does not pretend to be either comprehensive or correct on all aspects of the variable and rapidly changing dairy scene in China. Indeed, much more can be done on some of the calculations and arguments, but detailed work is beyond this assignment. No great changes are expected in that respect on the essence of the conclusions. An annex will be made available with more examples, background-information and literature-references.
Comments and suggestions are very welcome.

Pictures on the front page from left to right:
a) proud owners of a medium-scale mixed farm in Henan, the base of a large potential to produce more and better milk; b) processed dairy products on the way to consumers in Zhengzhou; c) a banquet in Hohhot where milk has a traditional role; d) an artist impression of modern large scale dairy production units in Harbin (right).

Preface

This document summarizes the results of an interdisciplinary study on dairy chains in China. It focuses on variation and change in a wide range of production systems across the country. It identifies problems and opportunities for dairy development, using central notions such as '*quality*' and '*the chain*'. It distinguishes the need to work on product quality for the short term and on process quality for the long term, even if those are two sides of the same coin. To add depth of analysis the report also discusses hard, soft and complex aspects of dairy development, respectively issues of biophysical nature, of mindset and of system dynamics.

The report is meant for chain managers and decision makers from the private and public sector, including stakeholders from business, policy, research and education. It cuts corners to gain on overview and to keep arguments simple. More elaborate arguments and calculations are beyond the scope of this report. They are left for further work and they are not likely to greatly alter the essence of the conclusions.

The broad approach was possible because the project team consisted of specialists on agronomy, dairy production, collection and processing. Aspects of marketing are left out due to lack of time and resources. Earlier versions of this report were discussed during meetings China and the Netherlands. This version is circulated to inform project partners and other stakeholders about the tentative results, as well as to invite suggestions for improvements. An annex is being prepared to provide more examples, background-information and literature-references.

The official name of the project reported here was '*sustainable development of the dairy sector in China*', and it was sponsored by the Dutch Ministry of Agriculture, Nature and Food Quality (project no BO-10-006-16). Thanks are due to our colleagues in The Netherlands and China, from both the private and the public sector. At the risk of forgetting some people we mention Arend Jan Nell, Paul Goethals, Mees Struys for his comments on core competence, dr. Gao Tengyun and his colleagues / students of Henan Agricultural University, Dr. Li Shengli with his staff and students of CAU in Beijing, Henk Sijtsma and the people at SIDDAIR and Huahuaniu in Zhengzhou, Dr. Dinghuan Hu of the CAAS, Dr. Le Dexun and his Yili colleagues in Hohhot, Dr. Jun Bao and Dr. Zhang Yonggen in Harbin, Gerard Nelis and Bram Wouters in the Netherlands, Yang Zhengde and Wang Huashu in Guizhou, Yaowen in Nanjing and Wageningen, Ma Mei in Beijing, Lu in Wageningen for the final picture of eroded hills in Northern Shaanxi province, and Rinske and the typists. Last but not least we thank Henk van Duijn and Gabrielle Nuytens at the Royal Netherlands Embassy in Beijing, as well as Erik Baudoin and his staff of NABSO-Harbin for their support and critical questions. We hope that this report triggers useful debate for follow up, we look forward to receive comments and suggestions, and we hope for continued collaboration in this exciting area of work.

China / The Netherlands; September 2007

Hans Schiere	WUR-WI	info@laventana.nl
Kees de Koning	WUR-ASG	kees.dekoning@wur.nl
Zhang Xiaoyong	WUR-LEI	xiaoyong.zhang@wur.nl
Huib Hengsdijk	WUR-PRI	huib.hengsdijk@wur.nl

Abstract

Change and variation.

Dairy production in China is changing rapidly [over time] and it will continue to do so in the near future. It also varies [in space] across the various agro ecological and socio-culture conditions of the country. This report on '*quality*' in the chain avoids to merely reviewing well-known data about different production conditions. It does aim, however, to give a framework for actions on sustainable development regarding quality for the short and long term. The report addresses issues of technology, mindset and chain dynamics, so-called hard- soft and complex system aspects. The report is meant for change agents in the dairy sector from business and policy to research and education. The report uses chain analysis to describe *change and variation* in Chinese dairy and to suggest action for '*product-*' and '*process* quality'. It is based on a quick scan of dairy chains, especially in the North, the North East, the Central Plains and the Southern Hills. The 'chain' in this report reflects the production process from soil and seed via farm-design to milk collection and –processing. Issues of marketing are mentioned only briefly due to lack of resources.

Dairy systems and milk quality on short and long term.

For clarity of argument this report distinguishes between '*product quality on the short term*' and *'process quality on the long term'*. These two notions are strongly related and the basics of the chain approach are the same for all dairy systems, but priorities differ between systems in time and space. Therefore, this report categorizes the variation of dairy production systems and chains in China, based on differences in:

- distance to urban centres (with changing price-ratios for feed and milk)
- resource use and availability (from the dry and cold North to the humid and hot South),
- design of dairy production system (from mixed to specialized),
- milk collection patterns (from informal to formal)
- quality management systems (from bulk to quality milk).

'Product quality' for short term work refers to aspects as microbial quality, cell-counts and milk composition, mostly using methodologies such as ISO and HACCP. Long term Issues are discussed in terms of *'process quality'*, with aspects of sustainable development and resource-use efficiencies associated with notions of Good Agricultural Practices (GAP). And indeed, management for better product quality on the short term can lead to higher yields and more efficient resource use on the long term.

Not one size fits it all.

Great differences exist in production methods and resource use between dairy systems as described in the five cases, i.e. '*not one size fits it all"*. Much can be gained by using variation of production-, collection- and processing systems as opportunity rather than as problem. We call this the first opportunity for development since for example, feed production across China varies from <500 to >25.000 kg dry matter per hectare and water use varies from what we call the 20 to 2000 litre range per litre of milk. That allows identification of efficient dairy systems suited to local differences, with a bigger role for mixed farms than often recognised. Properly *and* tailor made feed-, breed-, health- and excreta management is crucial and appropriate technologies are suggested in this respect.

Small and mixed farms, problem or opportunity.

The large range of production systems and –chains also implies variation in collection and processing. Most milk comes from mixed and small farms (estimates range from 70 to 80%), with the remainder from large, specialized and high-tech units. Remarkably, resource use tends to be more efficient at smaller and mixed than at large and specialised farms, but product quality tends to be more critical at the smaller farms. Much commercial, ecological and social opportunity can thus be gained by achieving a new balance between development of the large sector and the small- and/or mixed farms. In fact, it would help to make the poorer and smaller producers into resources rather than problems for rural change. That is the second opportunity for development identified in this report.

Short term product quality.

Product quality in terms of milk composition and bacteriological aspects is perhaps the biggest short-term concern. Chain approaches and technologies are suggested to improve this 'product' quality. Milk product quality is important for public health and it becomes commercially interesting when added value products are to be made (e.g. desserts, cheese etc.). For the short term we suggest a focus on product quality and follow up work in that respect is going on while this report is written. Much is gained if better milk quality can keep the majority of [also smaller] producers on board, the third opportunity for development.

Long term process quality and 'core-competences' of dairy.

Process-quality' relates to the way the milk is produced. It is a long term issue, referring to concerns like resource use (fossil energy, water, farmers' skills and biodiversity), balanced growth, the environment, etcetera. This report identifies challenges and options in this respect, the fourth opportunity for dairy development. We recommend [workshops and studies] to identify promising work and scenarios in China and abroad, new agenda's for teaching at universities, as well as changing R&D and policy priorities. The 'core-competence' of dairy as engine for rural development can only be realised with creative and tailor made solutions, rather than with standard approaches. Examples are given from within and outside China where dairy has roles beyond production of milk alone, providing rural income and/or re-generating resources such as biodiversity, soil fertility, etc.

Major recommendations

In terms of priorities we suggest that:

- work on product quality should distinguish between smaller and informal versus larger and formally organised producers (Ch 3.4 and 3.5). The large potential of small producers is underutilized, i.e. action for improved product quality is a key to unlock this vast potential,
- priority attention needs be given to short term action on product quality by use of methodologies such as HACCP, and as now done in a follow up project (Ch 2.3.5),
- work to further develop Chinese dairy should be tailor made and innovative, based on specific needs of given production systems and chains (Ch 3),
- a new balance is needed between the attention for mixed and specialized production systems, of which mixed farms may produce most of the milk (see above). This will help to improve resource use efficiency, also achieving more balanced development while increasing total milk supply,
- long term opportunities lie in process quality and GAP with respect to resource use efficiency, eventually strengthening an already emerging process of consumer awareness and labelling as in the case of 'green' milk.

Concluding

Short term opportunities lie in use of existing technologies for better milk production and product quality. Long term opportunity lies in (re-)design of dairy systems for process quality that use opportunities of local variation and local priorities. This might in one place imply a focus on dairy for balanced growth. Elsewhere it can aim to regenerate degraded resources (e.g. reducing erosion and replenishing water resources). Use of adapted breeds might serve concerns on biodiversity and resource use efficiency, as well as commercial interests of an industry that needs to produce cheaper and better for a demanding market. We envisage a market where milk is labelled for environmental impact where consumers pay accordingly. In that sense the dairy sector has unique core competences for sustainable rural development that are thus far by and large untapped.

1. Change and variation of dairy in China, an introduction.

1.1. Unprecedented change

The Chinese dairy sector grows *and* changes at unprecedented rates, in spite of short term ups and downs. Till only a few decades ago much of the dairy sector was concentrated in pastoral regions and around cities of the plains. Only in recent decades the sector has spread over larger areas of China while total production and product mix changed greatly (Fig. 1.1). Much of present production is based on standard management concepts, recently there appears to be more interest for new approaches. This report uses the notions of product and process as central theme to explore the problems and opportunities in Chinese dairy chains.

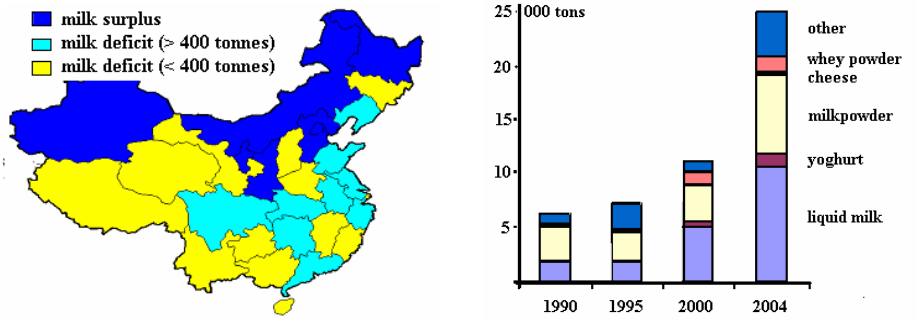


Figure 1.1. Regional variation of milk production and consumption in China (left), with change of production volume and mix (right), as based on RABO (2006).

1.2. Variation in production and consumption

Major drivers for changing consumption patterns in China are the increased incomes of urban people and a tendency to modernization. Also, the government actively stimulated milk production and consumption, for example via school-milk programs and using special development funds for production and processing of milk. However, the large variation of production systems makes it misleading to generalize. Therefore, this report analyses and describes variation across a wide range of Chinese dairy chains. It aims to identify bottlenecks and action for better milk quality by taking variation and local priorities as an opportunity rather than a problem. Examples of emerging concerns are milk quality and public health, total milk supply, issues of balanced growth and environment. They combine with those of commercial interest, e.g. the need for more milk, and the development of new products with '*added value (deserts, yoghurts)'* and '*organic milk*'. At this very moment the dairy sector operates in markets where competition increases and where supply of milk runs short of planned capacity. Such pressures are likely to lead to increased diversity rather than to further standardization. Use of tailor made approaches may need to become rule rather than exception, as described in the following chapters.

1.3. Target audiences and central themes of this report.

This report is for all public and private change agents in the dairy sector. It first identifies opportunities for action on the *short* term and across the chain, based on local differences. It then proceeds to define R&D priorities for the *long* term. The '*chain*' is the first central notion in this report, referring to the '*related set of activities from seed and feed to consumer',* or parts thereof (Ch. 2). *'Variation'* is the second central notion and 'quality' is the third, for the sake of easy argument divided into:

- product quality for short term action (e.g. milk composition and microbial contamination).
- process-quality for future developments (e.g. issues of environment and balanced growth).


Photo 1.1. Varying production conditions and markets in China, illustrated by cheese production in pastoral areas (left), by a display of industrially processed milk (centre), including lactose free milk (right); all from Inner Mongolia.

1.4. Making sense out of the variation.

The description of variation in Chinese dairy systems causes problems as well as opportunities:

- the variation of systems and chains makes it hard to suggest generalized action, but it can help to see patterns that remain hidden when focusing on only a few specific chains (see Ch 3).
- many statistics are available that contradict each other or that do not address specific questions that one has in mind, a problem overcome by use of expert advice and literature data.
- all stakeholders have different interests, even if they all work for the same sector, but we assume a central role of the government as chain manager (sometimes shared by industry and/ or middlemen).

The research team consisted of specialists from different scientific backgrounds. Sometimes this caused confusion but more often it created new understanding, beyond repetition of known facts and opinions. This report uses the results of a 'quick scan' across dairy production systems and their associated chains in conditions ranging from:

- being near to distant from cities, resulting in different methods to feed, breed, process etc. (Ch 3.1)
- cold and dry to hot and humid conditions related to fodder production and resource use (Ch. 3.2),
- mixed systems in remote hills to specialized systems in the plains, with big differences in terms off resource use efficiency (Ch. 3.3),
- informal to formal milk collection chains, with aspects of chain organization and relative importance of the different chains (Ch. 3.4),
- bulk to specialty markets in terms of interventions for improved milk 'product-' quality (Ch. 3.5).

1.5. Tailor made versus standard approaches

Concluding, this report chose for a description of variation and tailor-made approaches rather than to identify generalized actions. The entire dairy sector can gain from use of local differences, especially in its present stage of growth where initially successful approaches have to be reconsidered and where new ways are to be sought. This is a special time in the Chinese dairy history to explore and exploit opportunities for short and long term. It can use both known concepts of product quality and experiences on process quality from within China and beyond. It is then crucial to use the core-competences of dairy in terms of providing valuable food and income in a sustainable way (Ch. 4 and 5).

2. Qualities and dairy chains.

2.1. Product and process-qualities of milk.

Milk is one of nature's most complete foods, and a valuable raw material for making of yoghurts, desserts, cheeses or even more sophisticated products. The *product quality* of milk has to be assured both when sold directly (public health and consumer taste), and when used for processing into value added products (Photo 2.1). Apart from a value as foodstuff, milk also has broader *process qualities*, e.g., as tool for rural change and even for resource regeneration (Ch. 4). A guaranteed product requires involvement of all stakeholders in the chain. It also requires attention to issues ranging from feed supply to attitude (=mindset) and skills of farmers, managers, milk collectors, processing companies and retailers (Box 2.1). Each one of these has a specific role to safeguard safety and quality of the products and processes.

Photo 2.1. Milk sold in pasteurized form (left), as higher added value product in a supermarket (centre), and as special quality yoghurt promoted by 'Wonderful foods' in the streets of Harbin (right)

Box 2.1. The Food Chain Approach, Quality Assurance and Good Agricultural Practice.
A key-word for guaranteed quality is the Food Chain Approach and Quality Assurance. In that sense the FAO defined the Food Chain Approach to stress that responsibility for supply of safe, healthy and nutritious food is shared along the entire chain from production, via processing and trade to consumers. Stakeholders include farmers, suppliers, advisors, milk collectors, laboratories, food processors, transport operators, distributors and consumers, as well as governments that have to protect public health, among others via food safety. Such a holistic approach requires both an enabling policy and regulatory environment at national and international level with clear rules. It also requires the establishment of food control systems and programmes at national and local levels through the whole food chain. For example, in Europe the EFSA (European Food Safety Authority) was established by the European Parliament in 2002. This followed a series of food scares in the 1990s (e.g. BSE, dioxins) which undermined consumer confidence in the safety of the food chain. EFSA closely works together with national Food Safety Authorities, mainly focussing on Risk Assessment and Risk Communication to help EU, national authorities and industry in establishing food and food safety policy and legislation. In addition food production around the world also has to respond to increasing concerns regarding sustainability. Global initiatives like Good Agricultural Practices (GAP), Sustainable Agricultural Initiative (SAI), EurepGap and other quality programs reflect these developments. Such initiatives are likely to be major driving forces to implement future dairy chain programs around the world (see also box 4.1).

2.2. Farm level quality.

On-farm practices should ensure that milk is produced by healthy animals under acceptable conditions, and in balance with the environment. The Chinese dairy sector is familiar with quality management (Photo 2.2), but application of the principles is still in its early stages. Thus, much potential exists for programs on improved raw milk quality through payment systems, training of milkers, improved milking methods, quality assurance and the like. This improves product quality and it is also likely to increase yields via better health and animal management. Incorrect farm level management can result in off-flavour; bacterial contamination, high cell counts and other problems resulting in decreased milk quality. Beside loss of income for farmers the low milk quality also leads to higher processing costs at the dairy plant, re-call actions and to lower sales of dairy products. Processing into high added value dairy products requires excellent raw milk quality having low bacterial counts, somatic cell counts and absence of antibiotics and other residues of products used during the production process along the chain. All quality assurance programs start with an analysis of [parts of] the dairy production and processing chain.

Photo 2.2. Assuring product quality from a small farmer at a collection centre near QinDao (left), at a processing plant in Guizhou (centre), and labels with cow and clover leaf [hardly visible] on the left side as mark of 'green' process quality, also in Guizhou (right)

2.3. The chain approach, basics and variations.

The basics of any chain approach are to specify and relate the various parts of a production process. The chain itself can be defined as:

> *a system whose parts include suppliers, production facilities, distribution services and customers connected by feed-forward flow of materials and feed-back of information and money*.

The chain can be long and short, i.e. the chain approach can be used for the entire process *'from soil and animal, to fork and spoon'*, but also for processes at farm and animal level. Ideally, chain approaches stress feedbacks and feed-forward, from consumers to processors / producers, and vice versa (Fig 2.1). A typical case of feed forward discussed in Ch. 5 is related to the possibility to change consumer taste to produce a product with better process quality. Distinction can be made between supply and demand chains (driven by resp. supply and demand), and other terminology such as value chain is used for essentially the same concepts. This report uses the term chain in a neutral sense unless otherwise mentioned. It focuses on the chain from soil and animal to 'fork and spoon' as a whole, but it also analyses parts of the chain when discussing feeding and collection. Last but not least, it also explicitly refers to work on relatively short chains where milk goes directly from producer to consumer. These systems are disappearing in China but they make come back in other parts of the world (Ch. 3.4).

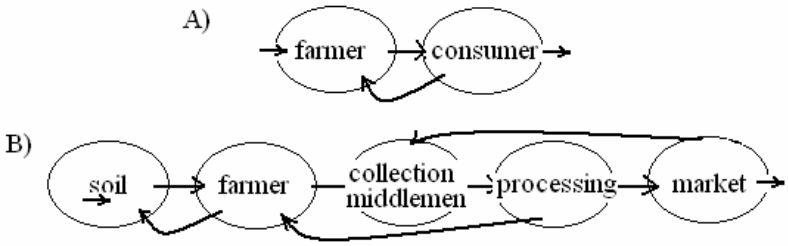


Figure 2.1. The basic models of short and long chains (resp A and B), with feedbacks and feed-forward links.

2.4. Chain approaches and change managers.

One basic concern of chain approaches is the need to identify a 'chain-manager' (Fig 2.2). A second concern is the choice of priorities and the need to balance between a focus on parts and the whole. The first parts of this report address issues of 'parts' of the chain, soil, feed, farm, collection and quality (Ch. 2 and 3). The second part addresses issues of the entire chain (Ch. 4 and 5). But throughout we assume that the main chain-manager of long chains in China is the government, either directly or via companies. Variations on the theme are possible, however, and the short chains of the Chinese spot market have no central chain manager (Ch. 3.4), except perhaps the middlemen who do not always put quality as a priority concern.

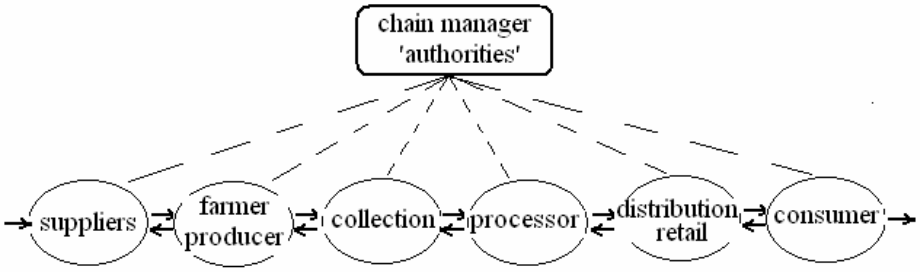


Figure 2.2. The chain based on fig 2.1, with a special place for the 'chain-manager'.

2.5. Problem trees and the priorities in this report.

The 'fish-bone' structure in figure 2.3 represents chain analysis for quality assurance from farm to collection in the form of the 'Pareto analysis', or also the 'problem tree'. It uses so-called soft and hard aspects of farm management and milk processing but relative importance of parts depends on the product to be processed. For example, preparation of UHT milk requires different points of attention than processing for cheese or deserts.

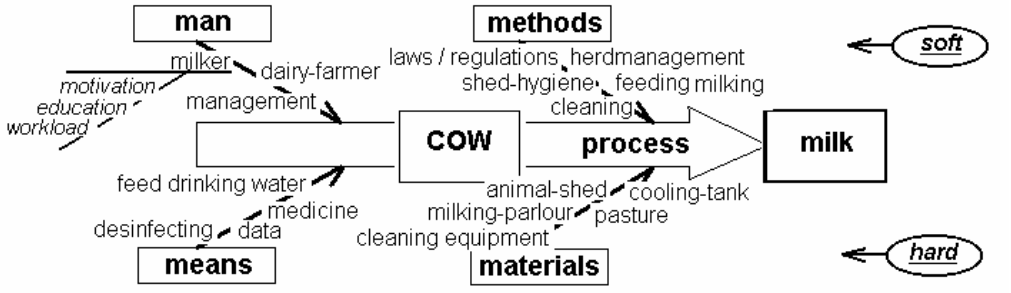


Figure 2.3. The Pareto analysis for milk quality assurance from feed to collection in which relative importance of the parts depends on the type of product. Note that the upper part refers to so-called 'soft' aspects such as mindset and protocols. The lower parts focus on 'hard' aspects such as inputs and machinery (see also box 3.1).

The focus of this report is on the use of chain approaches to improve short and long term quality in dairy chains. This is done by looking at parts and the whole of the chain in different production conditions, first to improve short term aspects of product quality like milk composition, bacterial quality etc., implying use of procedures like ISO and HACCP. After that, the definition of quality is broadened into aspects of process quality, including aspects like footprints, social conditions at the production site, food-miles and the like, based on tracking and tracing as well as reflecting notions from Good Agricultural Practices (Ch. 4 and 5). It cannot be stressed enough that the two are related, but they are here discussed separately to simplify the arguments.

3. Variation in Chinese dairy, five cases.

Dairy systems and -chains in China vary indeed from place to place and from time to time. A conventional way to categorize such systems uses what we call '*hard*'-data like herd size, yield and milk output for average systems across the country (Table 3.1). This report, however, proposes to use several categorizations of systems and chains in different ways, using what we call resp. 'hard', 'soft' and 'complex' criteria (Box 3.1.). It further assumes that variation in production systems and their associated chains is driven, among others by differences in price ratios, climate, soil type, history and policy. For example, farmers distant from cities face other milk / concentrate price ratios than farmers near cities (Ch. 3.1). And the dry and cold North has other production conditions and dairy chains than the hot and wet South (Ch. 3.2). One way to work with such variation is to do in depth studies of particular 'cases' (=farming systems and/or chains). Another way is to study 'cases' in relation each other. This report takes the second approach by studying the largest possible range of dairy systems to see how they change relative to each other. In this way we lose on details but we gain on general insight while being better able to suggest tailor made action.

Table 3.1. A classification of three major dairy production systems in China (RABO, 2006).

Farm category	Cow stock size (head)	Average yield (kg/acre)	Total milk output (%)
Household	1-100	2100	82
Large-scale private farms	100-1000	2900	14
State-owned farms	> 1000	3200	4

Box 3.1. Describing aspects of the dairy chain with different criteria.

The criteria / parameters of system performance in dairy chains can include aspects of people, planet and profit (Ch. 5), but also on milk yield, ecology, economy and society. This report uses criteria based on a distinction between so-called:

- '*hard criteria*': milk yield per cow, cash-flow, nutrient use efficiency, cow numbers, farm size, fodder produced, reproduction rates, farm incomes and/or cell counts in the milk.
- '*soft criteria*' like attitudes, mindset and 'values' such as market orientation, community mindedness, subsistence vs. cash orientation.
- '*complex criteria*' regarding system structure and change, scale of operation, rates of change, stability and resilience, interconnectedness, diversity and the like

This use of different criteria is maintained throughout this report, though not systematically, also to also reflect our stress on use of flexible and tailor made approaches based on local priorities. Such use of different criteria reflects a deliberate choice for an interdisciplinary approach and for a discussion of different chain aspects in different dairy production (cases 3.1 – 3.5).

Variation makes generalization misleading, i.e., it cannot suggest with generally valid actions and/or technologies. However, it does offer opportunities by helping to better use local differences for more efficient milk production. Good use of variation also helps chain managers, farmers and policy makers to better plan their actions. This chapter aims, therefore, to understand the changes, problems and opportunities in the Chinese dairy sector as they change 'in time and space', by plotting the systems along scales with different

- distances to urban regions, associated with different ratios of input / output prices (Ch 3.1)
- growing conditions for feed and fodder, from the dry cold north to the hot and wet south (Ch. 3.2)
- degrees of mixing, from dairy villages with mixed systems in the southern hills to specialized farms in the central and northeastern plains (Ch. 3.3)
- modes of market organization, from spot markets to collaboration chains (Ch. 3.4)
- production objectives, from producing bulk milk to milk for value added products (Ch. 3.5).

The sequence of cases reflects a choice to start with economics of milk production, proceeding via changes in the feed base as driver for changes in the production system, and eventually to four distinct modes of collection towards processing, i.e. from left to right in figure 2.1.

3.1. Variation and distance to consumers (Case I).

3.1.1. Cost of feeds and milk

Economics are a major driver for the changes in dairy production systems. Table 3.1.1 therefore plots the price ratios of milk and concentrate feed as a function of distance to an urban centre. Distance is a relative concept, i.e. large commercial producers distant to the city may have better access to urban markets than smaller producers near to the city but that does not alter the basic argument.

Table 3.1.1 Change in dairy systems and associated chains, here based on distance to the city and price gradients[1].

Particulars	Different production systems / chains			
	Biophysical aspects (hard system criteria)[2]			
- distance from the city	0 – 10 km	10 – 30 km	30 – 50 km	> 50 km
- price of milk (RMB/kg)	1.8	1.6	1.4	< 1.2
- cost of concentrate (RMB/kg)	1.4	1.6	1.8	>2.0
- benefit of feeding (RMB milk/kg concentrate) [3]	+1.3	+0.8	+0.3	-0.2
- `main production system and feed/fodder used	Stall feeding of concentrate and some roughage	Stall feed / graze concentrate and more roughage	Graze / stall feed concentrate and fodder	Mainly grazing / no concentrate
	options / suggested action to assure product quality[4]			
- need for cooling	Low	Low to medium	Necessary	Necessary if no on farm processing
- method of 'cooling'	NA	Tank	Tank	Plate cooler or on farm processing.
- quality risks	High because no cooling; related with farm size	for further research		Low if large farms with cooling, risky transport
- microbial aspects	Risky			In control
- composition	See table 3.3.1	see table 3.3.1	See table 3.3.1	see table 3.3.1
- quality control	Direct consumers	HACCP	HACCP	HACCP

1) this example represents an hypothetical but realistic case near Zhengzhou developed during a workshop in October 2006;
2) this table uses mainly 'hard' data; a more elaborate version with also soft and structural data is available on request
3) assuming that 1 kg concentrate yields 1.5 kg milk with good management, disregarding nutrients from fodder.
4) the lower half of this table refers to possible work on product quality, it does not necessarily describe the present situation

3.1.2. Soft and hard aspects of action for change.

The differences in dairy production systems and options for product quality in table 3.1.1 reflect trends that can also be arranged in other ways. Thus, the categorization in table 3.1.2 distinguishes chains with direct sales on the one hand, and chains with need for processing on the other. The trend in China is to ban direct sales for reasons of public health, but short chains are deliberately discussed. In the first place, they provide a substantial proportion of all milk produced in China. And secondly, there is an international trend to again allow direct sales for niche markets (Photo 3.3.2). Proposed hard- and soft system action for product quality in both categories of table 3.1.2 are identified with the Pareto analysis (Fig 2.3).

Table 3.1.2 Possible lines of action for product quality in two major producer groups (see text)

Particulars [1]	Small producers near consumers [2]	Larger producers distant form consumers [2]
	Soft aspects of the chain approach)	
The human factor	Create responsibility to consumers	Create attitude to stick to protocols
Methods	Establish local GAP protocols	Introduce (inter)national protocols like GAP
	Hard aspects of the chain approach	
Means	Emphasize the quality of inputs	Emphasize the quality of inputs
Materials	Use simple local systems for chilling, processing and storage	Focus on sophisticates equipment for longer shelf life and transport routes

1) see the categories of the 'Pareto' problem tree in fig 2.3
2) the columns roughly aggregate the production categories of table 3.1.1 into two major producer categories.

3.2. Dairy systems from the dry and cold North to the warm and wet South (Case II)

3.2.1. Feed supply and dairy chains, differences and similarities.

The effect of climate on dairy production systems and - chains occurs particularly through the feed base as here shown for three regions from North to South, i.e. Inner-Mongolia, Henan and Jiangxi (Photo 3.2.1). Feed availability is largely determined by drivers like temperature, radiation and water availability. And production of biomass can be quantified with plant production models. However, any broad brush method one is bound to err on details, i.e. specification is needed:

- in Inner-Mongolia we focus on a sparsely populated area with low rainfall, harsh and long winters and extensive grazing.
- Henan is one of the densely populated provinces of the centre, and a major production area for maize-wheat rotations. Our calculations focus on the region of the Yellow river basin around Zhengzhou with the Sino-Dutch dairy project SIDDAIR.
- Jiangxi is situated in the 'rice belt' of China with rice-based production systems in a sub-humid climate. Here we focus on potentials for dairy in rural areas at a considerable distance from cities.

Many other dairy regions in China fit in the range of systems described here (Photo 3.2.1). For example, pastoral systems in Heilongjiang resemble those of Inner Mongolia, and cropping systems of Heilongjiang resemble those of Henan, albeit with shorter growing seasons. The Guizhou region of chapter 3.3 takes an intermediate position between Henan and Jiangxi, again in spite of their differences. In Henan and Inner-Mongolia most of the low rainfall occurs during a relatively short summer period. Jiangxi is by the far the wettest region of the three, but total radiation is highest in Inner-Mongolia and lowest in Jiangxi, with Henan in an intermediate position. Daily temperature show similar trends in all regions, but differences between Jiangxi and Henan are more pronounced in late summer and winter with highest temperatures in Jiangxi.

Foto 3.2.1. Grazing of natural grasslands in Inner Mongolia (left), a peri-urban dairy near Beijing (middle) and the rice based livestock systems of Jiangxi (right).

3.2.2. Production situations and resource use scenarios.

Differences between regions depend on climate and soils, but also on management, e.g. choice of species, weed control, crop-protection, fertilizer and irrigation. The most important feed resources and their estimated yields in the three regions are therefore given for three management levels, using simple estimates and models to trigger discussion (Table 3.2.1). The levels of management represent possible technological interventions for dairy development as follows:

- *actual situation:* present practice, with yields reduced by weeds, pests, disease, prevailing weather and nutrient management.
- *yields only limited by water availability:* yields in this situation may be limited by water shortage for part of the growing season, while fertilizer is applied at conventional levels.
- *potential yield as determined by CO_2, radiation and temperature:* the crop gets enough water and nutrients and it is free of weeds, pests and disease. At full cover, the growth of field crops ranges from 150 to 350 kg dry matter per hectare per day (=potential growth rate & yield), conditions that represent intensive management.

Low soil productivity of natural grasslands in Inner-Mongolia, even under potential production situations suggests that this region is less suitable for intensive dairy production. One issue is the low milk density (=milk / area unit) leading to expensive collection chains. However, the vast natural grasslands provide a good base for extensive dairy and/or production of young stock. The short growing season limits crop production and one of the best alternatives to use the land resources in Inner-Mongolia is animal husbandry, alone or combined

with crops. Competition for land by other agricultural and urban activities is stronger in the Jiangxi and Henan provinces and comparative advantages of dairy farming are less obvious there, unless it considers the use of crop residues.

3.2.3. Feed production and animal yield, some simple models[1]

Use of expert knowledge and literature data makes it possible to estimate milk yield and resource use efficiency (table 3.2.1 and fig 3.2.1). The calculations are tentative but main points are likely to hold, i.e.:

- a large range exists in terms of animal production levels, from approx. 250 to 15000 lts/ha/yr
- much variation occurs in efficiency of fertilizer nitrogen use, from 0 to 80 g/ltr milk
- the irrigation efficiency varies widely, on what we call a range from <20 to >2000 lts/kg milk.

More basic issues can be raised, e.g. on the facts that efficiency of fertilizer use also depends on use of irrigation water, and that variation in water use depends more on method of calculation than on choice of data (ch 3.3). For example, irrigation water that is pumped especially for the production of fodder is an environmental cost. But if it is pumped for the production of crops one may argue that the resulting fodder (straw and stover) are produced free, as byproduct, and albeit of an inferior quality. The same is true for soil nutrients like nitrogen that have to be 'produced' for specialized systems, but that are recycled in mixed systems (Ch. 3.3).These arguments refer to issues of process quality that are discussed in chapter 4 and 5, illustrated in photo 3.2.2 and briefly as implications for product and process quality of milk in this chapter.

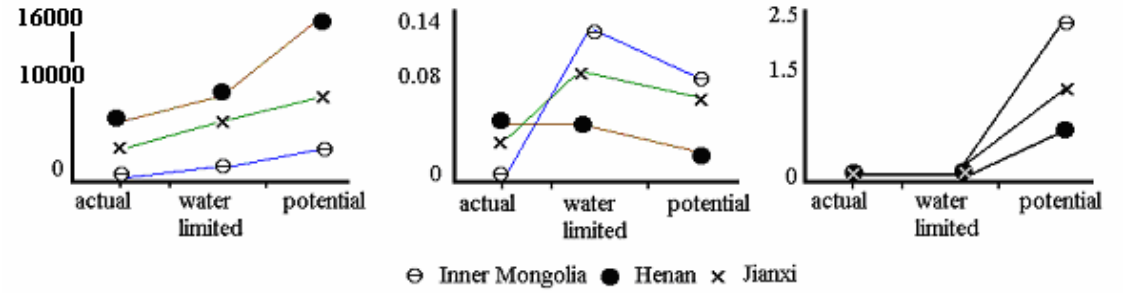


Figure 3.2.1. Range of milk yields as lts/ha/yr (left), resource use efficiencies as fertilizer nitrogen kg/ltr milk (centre) and water use as m^3/ltr(right) as tentatively calculated (see table 3.2.1). Milk yield per land area unit increases as conditions improve (from actual to potential) and as production shifts from North to South (left). However, fertilizer nitrogen requirements increase first, and decline again when more [irrigation] water is used.

Foto 3.2.2. Opportunities for process quality, in this case nutrient management through better urine-nitrogen collection. Left is a floor in animal housing (Inner Mongolia) that is ill equipped to collect urine. Bad excreta management in Harbin dairy villages is shown in the centre, and grazing tends to result in dung patches on the field with urine-nitrogen as invisible loss (right)). These process qualities are valid in all climatic conditions since they relate with management and farm design such as the difference mixed and specialized (Ch. 3.3).

1 These calculations are very tentative and in need of further work that is beyond the scope of this report

Table 3.2.1. Biomass production and resource use, approximated for production situations from North to South.

Type of biomass / feed	Production situations		
	Actual	Water-limited	Potential
Inner Mongolia			
Natural vegetation			
- Dry matter (t/ha)	0.5 (0.25 - 0.75)	2.0 (1.0 – 3.0)	3.5 (3.0 - 4.0)
- N-input (kg/ha)	0	150 (100 - 200)	175 (150- 200)
- Irrigation water (mm/ha)	0	0	500 (450 - 550)
Maize / Sorghum fodder		Cannot be grown well (see text)	
Henan			
Winter wheat (grain)			
- Dry matter (t/ha)	3.5 (2.5 - 4.5)	5.4 (5.2 – 5.6)	7.6 (7.4 - 7.8)
- N-input (kg/ha)	250 (100 - 400)	145 (140 - 150)	205 (200 - 210)
- Irrigation water (mm/ha)	0	0	325 (275 - 375)
Maize (grain)			
- Dry matter (t/ha)	4.0 (3.5 - 4.5)	4.6 (4.4 – 4.8)	8.5 (8.4 - 8.6)
- N-input (kg/ha)	250 (100 - 400)	135 (130 - 140)	255 (250 - 260)
- Irrigation water (mm/ha)	0	0	90 (70 – 110)
Maize / Sorghum fodder			
- Dry matter (t/ha)	8 (7 - 9)	9.2 (8.8 – 9.6)	17 (16.8 - 17.2)
- N-input (kg/ha)	250 (100 - 400)	230 (220 - 240)	425 (420 - 430)
- Irrigation water (mm/ha)	0	0	90 (70 – 110)
Jiangxi			
Maize grain			
- Dry matter (t/ha)	3.5 (2.3 - 4.7)	7.5 (7.0 – 8.0)	9.5 (9.0 – 10.0)
- N-input (kg/ha)	140 (50 - 250)	225 (210 - 240)	285 (270 - 300)
- Irrigation water (mm/ha)	0	0	180 (75 – 285)
Italian ryegrass			
- Dry matter (t/ha)	5 (3.8 - 6.2)	8.5 (8.0 – 9.0)	12.5 (12.0 – 13.0)
- N-input (kg/ha)	100 (0 - 200)	265 (250 - 280)	390 (375 - 405)
- Irrigation water (mm/ha)	0	0	145 (100 - 190)
Maize / Sorghum fodder			
- Dry matter (t/ha)	7 (4.6 - 9.4)	15.0 (14.0 - 16.0)	19.0 (18.0 -20.0)
- N-input (kg/ha)	140 (50-250)	375 (350 - 400)	475 (450 - 500)
- Irrigation water (mm/ha)	0	0	180 (75 – 285)

Note: this table uses only hard criteria based on literature; expert-panels can supply broader criteria.

Opportunities for dairy development in remote areas such as pastoral regions of inner Mongolia lie in, for example, development of local added value products, choice of hardy animals (yaks, crossbreds), focus on farmer training for product quality in remote conditions, besides redesign of grazing systems, critical use of inputs and so on for process quality. In contrast with Inner-Mongolia, dairy systems in Henan and Jiangxi are not associated with dust storms but they do face other environmental challenges. Dairying in these two provinces is intensifying, i.e. it depends increasingly on external inputs such as fertilizers, irrigation water (in Henan) and more specifically feed concentrates. The resulting import of external nutrients through fertilizers and concentrates has important consequences in terms waste disposal. These problems are more obvious and recognized in intensive pig and poultry systems, but until recently they received little attention in China. Concentration of dairy production in large specialized farms and so-called dairy villages increases the risk for nutrient loading of the environment. In current dairy production manure management is virtually absent and nutrient loading of the environment by run-off, leaching and volatilization are evident. Great advances on nutrient management must be possible, among others by better collection, storage and re-application of the nutrients, but also by re-inventing mixed farming as discussed in the next chapter.

3.3. From mixed to specialized (Case III)

3.3.1. Specialised and/or mixed farming.

Much dairy development focuses on use of specialized systems, a worldwide trend to get advantages of scale. That makes economic sense, but it overlooks that specialisation also has problems, e.g. in terms of pollution, while product quality in large units is not assured either. Issues of product quality in [small] mixed farms may be real but they could be made into an opportunity rather than a problem, especially because the smaller mixed dairy farms appear to produce most of China's milk supply (Table 3.1). Therefore, this chapter discusses dairy systems on a range from mixed to specialized.

Many forms of mixed farms exist but we refer only to –integrated- mixed farms where resources like feed and dung are exchanged between crops and animals (Photo 3.3.1). Unfortunately, mixed farming is often associated with 'small scale' and specialised with 'large scale'. But large farms can be mixed and small farms can be specialized (Photo 3.3.2). For example, dairy production can be mixed 'between farms' where [small] crop farms provide feed for [large] specialized dairy operations. Also, [large] dairy farms can supply manure to adjoining [small] crop farms. Internationally there is a growing awareness that mixing has advantages for both small *and* large farms.

Photo 3.3.1. Straw burnt near Guizhou on a diversified farm (left), but carefully bundled and stacked on integrated small mixed farms near Guizhou and Harbin where straw is (centre and right).

Photo 3.3.2. A large specialized dairy farm near Beijing receiving feed and returning dung to small surrounding farmers (left), and a large tomato grower (middle) using dung for biogas and fertilizer from adjoining –specialized- per-urban dairy farmers (right), both near QinDao.

3.3.2. Mixed vs. specialized, mindsets and policy choices.

Our discussion here on (dis)advantages of mixed and specialized dairy farms (Table 3.3.1) compares two systems as found in a) the southern hills (mixed) and b) in the central plains (specialized). Comparison of mixed and specialized dairy requires other mindsets than comparison of two specialized systems alone. In specialized farms it is rather easy to set the yield of one farm against the other without considering the effects on other parts of the system. But in mixed systems one has to look at the combination of functions, where the optimum yield of cows depends, among other on the possibility to use crop by-products and/or nutrient cycling. High milk yield in mixed systems are not necessarily as optimum as in specialised ones. Moreover, secondary benefits of dairy are more important in mixed than in specialized systems, e.g., where inclusion of animals in a crop rotation can help reduce dependency on agrochemicals. Last but not least, secondary costs of specialisation on social and biophysical environment tend to be underestimated.

Table 3.3.1. Characterizing [small] mixed and [large] specialized farms with their associated chains.

	Small dairy farm with some land, 3 – 10 cows & followers in hills, using crop residues	Large specialized herd, not much land, 300 – 1000 cows, irrigated fodder and much concentrate
Hard / biophysical aspects		
Breed (ideally)	Xbred / dual purpose breed / buffalo	Holstein and single purpose breeds
Optimal milk yields	2.000-5.000	5.000-7.000
Type/amount concentrate	Local grains / some premix <40%	Commercial concentrate >60%
Forage base	Crop residue	Crop residue & irrigated fodder
Fertility / health	may be critical	May be sub-optimal
Use of silage	Not much / dried straws	Essential unless fresh purchased
Metabolic problems	Low fertility, ketosis, Ca^{++}	Acidosis / displaced abomasums
Milk quality (contents)	Lower protein / higher fat	Normal or lower fat
Seed for forages	Local, if any	Local and/or commercial
Main product	Crops and cows, some manure	Milk
Nutrient accumulation	mainly urine losses but much recycling solid manure	Can be substantial Some recycling
Needs for irrigation	Nil to low	low to high
Soft / socio-cultural aspects / mindsets		
Social orientation	Family / village / survival	Business / city / expansion
Competition	Local	Regional
Literacy & access to media	Low	High
Main innovators	Government, dairy societies, universities, farmers	Dairy companies, investors, government
Complex / structural aspects and trends in the farm system		
Organization of the chain (see Ch. 3.4)	Local (spot market)	Regional / national (entrepreneurs / collaboration)
Added value	Undeveloped	Coming in focus
Ownership)[2]	Local	External
Recycling	predominant	Exception
Scale	Family-level	Community / regional
Control / decisions	Local	External
Balance rural/urban	towards rural	towards urban
Footprint	Local	(inter-)regional
Social capital / reserves	Internal	External
Resilience / adaptability	Resilient / flexible	Stable / rigid

NOTE: for explanations about hard, soft and complex criteria see box 3.1

3.3.3. Process quality, the 20-2000 range and mixed farming.

Advantages of mixed systems refer especially to issues of process quality, e.g. in terms of:

- water use efficiency can be high in mixed systems, reflected in what we call the 20 - 2000 ltr range. The reason is that cultivation of fodder-biomass has water requirements in the range from 300 -2000 lts / ltr milk, but crop residues are produced rather free as by-product of grain implying only a water need for drinking, cleaning and processing!
- soil conservation through planting of perennial fodders on slopes and ridges for erosion control can be made attractive through dairy in mixed systems
- inclusion of animals in cropping systems can help to widen rotations, potentially reducing the use of agro-chemicals and introducing the possibility for nitrogen binding through use of legumes (saving on fossil energy to make fertilizers).
- labour use in mixed systems tends to be higher than in specialized systems, i.e. mixed systems are a labour and income opportunity for rural development.
- resilience and adaptability of systems such as in mixed farming tends to be much higher because their diversity and risk-bearing capacity

It is crucial indeed to stress that livestock as part of mixed systems can operate at lower levels of fossil resources like oil, fertilizer and/or water. They also are a labour opportunity, thus giving a better process quality than the specialised systems. It is an [unfortunate] opportunity that a wrong notion of low product quality from small mixed farms is held against this otherwise efficient form of dairying (photo 3.3.3). Gains in product quality from mixed farming can help to unlock the vast potential of milk supply that is produced at little or no cost for society and the environment. This point is a central issue in our discussion about the need to balance attention to mixed and specialized farming.

Photo 3.3.3. The contrast between small mixed farms as in the Guizhou hills (left) and Henan (middle), with large specialized farms such as near Harbin (right). Note, the Harbin farmers are actually independent units of what used to be a much larger and more difficult to manage government farm, '*so much*' for advantages of scale.

3.3.4. Product and process quality, suggested lines of action.

Interventions on product quality do not differ much between mixed and specialized, unless the distinction mixed-specialized is [wrongly] confounded with the distinction between small and large. Great differences between mixed and specialized do not exist, regarding hygiene. They may exist in terms of protein / fat ratios or specific fatty acid-contents in milk due to use of crop residues in mixed systems. But those differences are not yet very relevant for the sector in general and they are much smaller than those due to hygiene. Therefore we only suggest interventions on process quality, i.e. aspects related with farm design and management (Table 3.3.2), again to trigger discussion rather than to be comprehensive.

Table 3.3.2. Suggested action (tentative) for increased product- and process quality in mixed and specialized systems.

	Mixed	Specialized
Feed	- supplement to improve utilisation of crop residues - establish grain crops with better feed value	- select other fodder varieties in terms of quantity and quality - improve fodder conservation
Breed	- crossbred and dual purpose cows - buffaloes in tropical systems	- focus on robust and specialized dairy breeds
Health	- address fertility and metabolic issues due to underfeeding	- avoid fertility and metabolic problems due to overfeeding (acidosis) and stress ..
Farmer skills	- focus on combining crops & animals, including aspects of on farm integration	- focus on parts and business skills
Soil nutrients	- use crop residues for feed, mulch, fertiliser - legumes to bind nitrogen - deep rooting [tree] crops to recycle leached nutrients.	- Fertilisation and use of deep rooting perennial fodders - Seek alliances for nutrient and feed management
Farm waste	- use for soil and energy	- Use for energy and soil

3.4. Milk collection structures of the chain (Case IV).

3.4.1. A categorization of collection systems, from informal to formal.

Like everything else in China also the organization of the dairy collection system occurs in many forms. The main chain structures in terms of collection are here categorized into four 'modes', ranging from informal to formal ones (photo 3.4.1). That approach is based on visits to Inner Mongolia and Heilongjiang, but several discussions in other parts of China and the world suggest that it represents rather universal patterns.

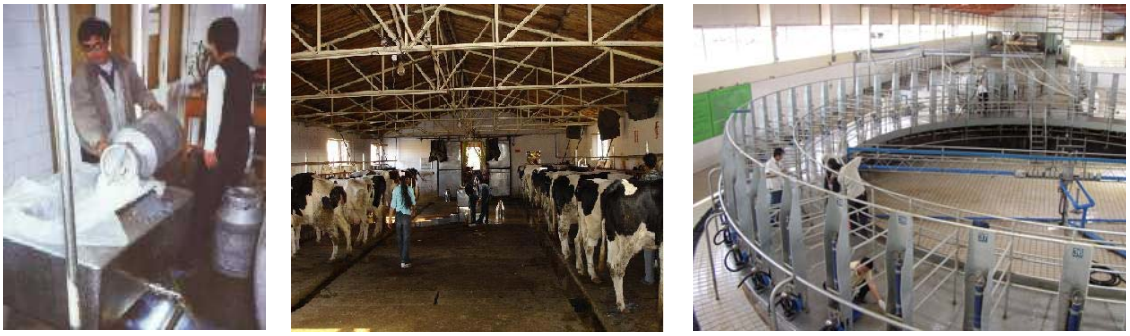


Photo 3.4.1. Different modes of milk collection and production with middlemen on a spot market near QinDao (left) and in a dairy colony in Wulanhot (centre), as well as a large dairy farm of the collaboration mode in Inner Mongolia (right).

The basic four modes for market organization distinguished in this report are (see also fig 3.4.1):

- *the Spot Market Chain*: a traditional dairy [supply] chain where farmers milk their cows and where they bring the milk directly to retail markets for individual consumers without any treatment of the milk. The chain is simple, short, local and cheap. It almost disappeared around big cities of China during the last five years but it is still found in areas where people like fresh milk as part of their culture. Reasons for disappearance of this mode in big cities are twofold. One is the emergence of large processing industries during the last decades that refuse to take milk from spot markets. Another is that urban consumers are increasingly aware of food safety issues due to awareness campaigns from the Chinese government, i.e., they decline to use fresh milk.
- *the cooperation chain (also called 'village milk collection centers or dairy villages).* This mode occurs where individual farmers milk their cows in central milking stations. From there the milk is taken to the processing industry that cooperates with private investors to build such milking stations. It also provides loans and technical assistance in running a milking station. Most of these investors are village leaders or local business men in a role of middlemen who have not always a mindset towards production of clean milk. Farmers walk their cows twice a day for milking and according to preplanned schedules. Each time the milk is weighed and farmers are paid at the end of the month.
- *the relation-based alliance*: *(in this report referred to as 'entrepreneurs')*, a mode that consists of partners that include farmers, processors, local government and the financial sector. A typical case is the so called Dairy Garden from north eastern China. It starts with networks between dairy processors and local government. Local government would sell a large piece of land (often >20 ha) to the dairy processors at a favorable price. The processors build the dairy garden with milking stations, lecture halls and individual farm units (50 to 60), each with 20 - 50 cows. After construction the processors sell or rent the units to people interested to be dairy farmer in the new garden. Proximity of farmers in one 'garden' facilitates management of activities such as feed purchase, disease control, milking, etc. Local government encourages banks to provide loans to farmers and milk processors tend to play a role of guarantor for poor farmers. The main objective of this type of operation for a milk processing company is to receive good quality of milk.
- *the collaboration chain*, based on mutual commitment between partners that consider reliable partnerships to be strategic for their business success. The relation between large pasture dairy farms and processors in Inner Mongolia and Heilongjiang is of this kind. The farms often have hundreds of hectares pasture-land, mostly irrigated, and they can be owned and managed by the dairy companies themselves. The farms have capacities of more than 1000 dairy cows. Processing companies support most aspects of these farms, from milking equipment to quality control system, often to serve as

showcase to attract outsiders. Processing companies can sign contracts with the farms, specifying quality and quantity to be delivered. Also, the farms and processing companies can jointly develop new products such as organic milk.

3.4.2. Limitations and relevance of the four modes.

Local differences blur the general picture but this report uses the categorization of these four modes as framework to discuss policy choices on product and process quality. Figure 3.4.1 simplifies the modes and table 3.4.2 characterizes the modes in terms of hard, soft and complex criteria.

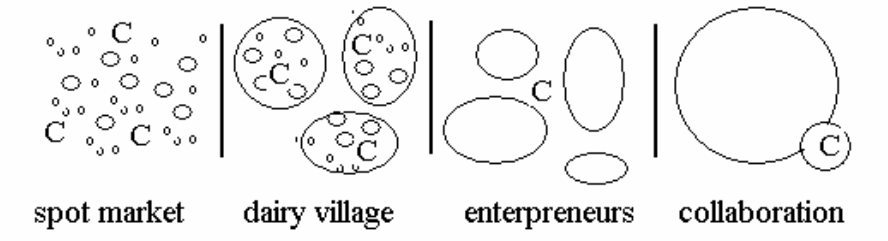


Figure 3.4.1. The four chain modes with dots and circles representing farms of increasing size. The "C's" are collection centers shifting from middlemen (left) into direct negotiation (right). Not all modes exist in all regions and especially the entrepreneur mode is subject to local differences.

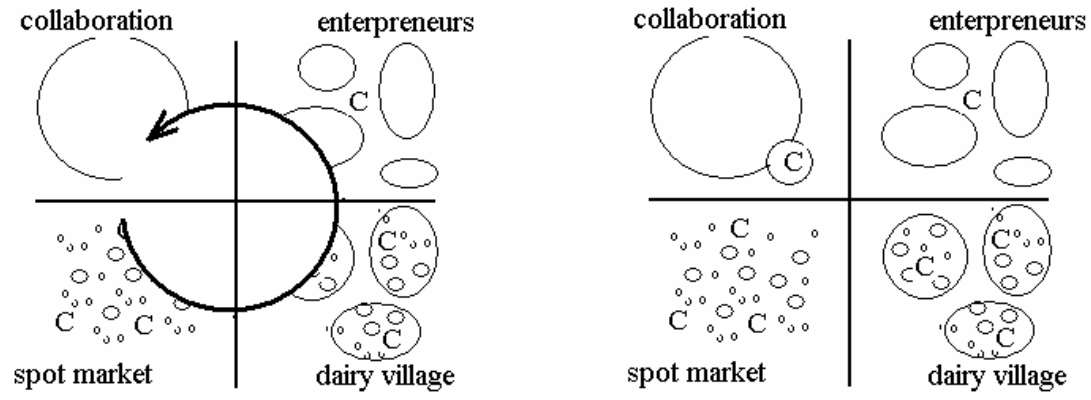


Figure 3.4.2. The four modes arranged in a 'quadrant' with an arrow that suggests progress (left) and more neutrally without the arrow (right).

Importantly, the 'spot market' is often said to be fading in China, but it still produces much milk, mainly run by middlemen. Another major source of milk supply appears to be from dairy-villages (Table 3.1). Good data are hard to get but implications of the quadrant are hard to ignore, including issues such as:

- the role of middlemen as chain manager 'In control' of product quality (Ch. 3.5).
- most milk is still produced in '*spot-markets*' and '*dairy villages'* (Fig.3.4.3),
- the notion of 'progress' from '*spot-market*' to '*collaboration*' as suggested with the arrow in figure 3.4.2 is disputable since spot market tends to be mixed and collaboration tends to be specialized, while we do suggest that mixing might even be a dairy farming mode of the future (Ch.3.3),
- successful efforts to improve product quality in the spot market and dairy villages will unlock a significant potential of milk produced with high process quality.

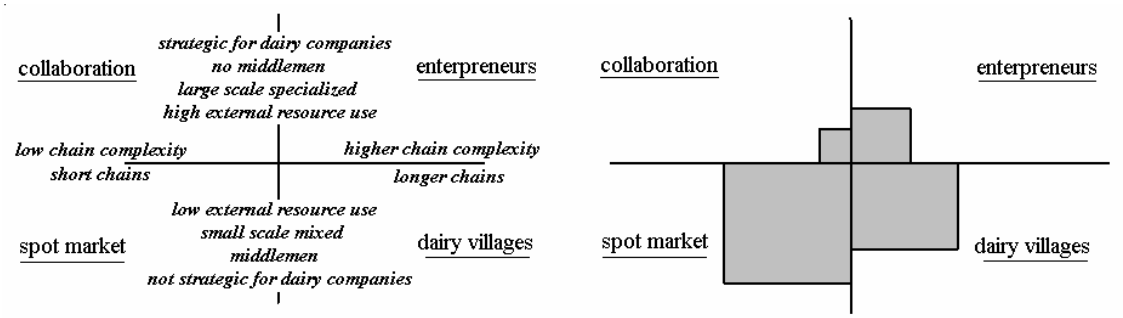


Figure 3.4.3. The characterization of the four modes in a quadrant (left), and their relevance in terms of contribution to the total milk supply, tentatively indicated with the area of the blocks.

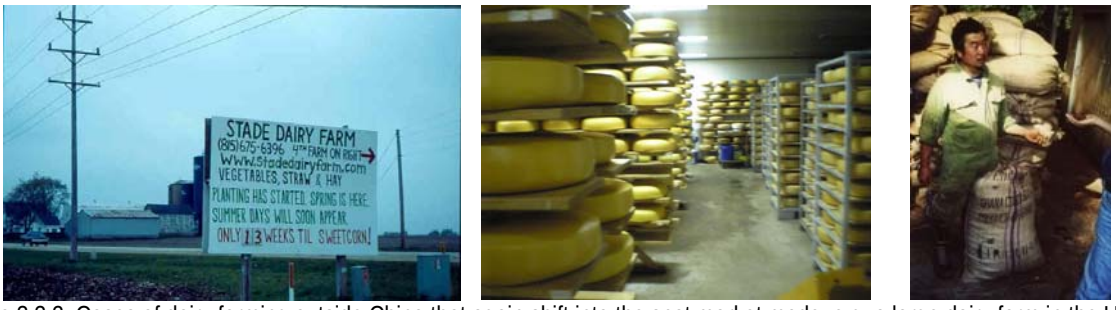


Photo 3.3.2. Cases of dairy farming outside China that again shift into the spot market mode, e.g. a large dairy farm in the USA with 'on farm' sales (left), export quality cheese from on-farm processing in the Netherlands (centre) and an urban dairy farmer in Tokyo with direct sales to consumers (right).

Table 3.4.2. A characterization of the four dairy chain modes.

Profiles	Spot market chain	Cooperation chain (dairy villages)	Relation-based (large entrepreneurs)	Collaboration chain
	Hard System Characteristics			
Scale of farm	1 or 2 cows	5-10 cows	30-50 cows	1000 cows
Popular period	Until recent	Starting middle 90s	Starting later 90s	After 2002
Yield	3 tons	4-5 tons	5-7 tons	8-9 tons
Milk miles)[1]	Very short	Longest	Longer	Shorter
Milk quality	Uncertain	Unstable	Guaranteed	Best
	Aspects of mindset and attitude (social system characteristics)			
Objectives	Extra income	Large quantity	Milk safety	Milk quality
Price formation	Open negotiation	Set by Processing companies	Set by processing companies	Bilateral negotiation
Power of farmers	Weak	Weak	Stronger	n.a.
Power middlemen	Strong	Strong	Weaker	n.a.
	System and chain structure (as it is, see note 4)			
Degree of chain integration	Not at all	Somewhat	High[2)]	Fully integrated (on one to one basis)
Community orientation[3)]	Very strong	Strong	Not much	Not applicable
Track & Trace	No existing	Very weak	Weak	(internally) transparent
Farm system	Mixed family farm	Dairy family farm	Professional farm	Industrialized farm

1) Milk-miles refer to distance covered between producer and consumer; 2) see controversy between organised and non-organised; 3) community orientation refers to social stability, a typical soft system characteristic in development planning; 4) here we report the situation as it is, the Pareto can used to establish priority action (see Ch. 3.4)

3.5 The Dairy Chain; from bulk to quality (Case V)

3.5.1. The challenges.

The dairy industry has to both collect sufficient milk (bulk) and good milk (quality) to keep its market share from different producer regions and for different markets (Photo 3.5.1). Sourcing of quality milk is necessary for reasons of public health but also for processing of added value products like cheese and desserts. So far the industry tends to focus on 'bulk' production of milk with a slow shift in emphasis to 'quality'. As said before, product quality refers to both aspects of composition in terms of fat and protein content as well as to aspects of bacterial counts, cell counts and [antibiotic] residues in raw milk (Table 3.5.1). The clear relation between milk product quality and -yield adds to the urgency of work on quality. Process quality in his sense refers to issues of resource use efficiency and footprints, also directly affecting aspects of total yield (Ch 4 and 5).
Use of the four chain modes of chapter 3.4 helps to set priorities for work on transitions from quantity to quality. For example, family farms of spot markets and dairy villages account for some 80% of all dairy cows and roughly the same amount of milk. That large potential, however, appears to get little official attention and many of these farmers start dairy without much experience or tradition on milk quality. Good data are hard to find but the general opinion is that milk produced by village milk centres and small family farms cannot meet [inter]national standards (Table 3.5.1). Larger, specialized and high-tech dairy production units of the 'entrepreneur' and 'collaboration' mode are generally believed to perform better in terms of product quality but no good data can be found on that either. Success in getting improved product milk quality from farmers of the spot market and dairy villages is an easy way to a) tap into a large volume of milk, and to b) improve the process quality.

Photo 3.5.1 Different parts of different chains with different quality management characteristics, e.g. small farmers that deliver milk at a collection centre in the North (left), traditional milk products marketed as local tourist attraction in Inner Mongolia (centre) or as part of an array of added value products including cheeses in demanding markets (right).

Specifics	Generally quoted quality figures on milk quality in China (with range)	Allowed according to EU-standards
-Total bacterial counts (TBC)	>1.000.000	<100.000
Bacterial colonies/ml	Often up to 4.000.000	
-Bulk somatic cell counts (BSC)	>1.000.000	<400.000
Cells/ml	200.000 – 4.900.000	
-Antibiotics	No data available but generally seen as big problem	None

Table 3.5.1. Quality of milk in China, based on informal discussions at the 2006 Shanghai World Dairy Summit.

3.5.2. Quality, quantity and suggested action

The lack of attention by producers, middlemen and processors to issues of milk quality is a problem and an opportunity. That is also true for the indirect contact between producers and processors via middlemen, combined with a continued shortage of raw milk. The indirect contacts and the shortage of milk imply little stimulus for individual producers to ensure milk quality. But things are changing and much is possible if the causes are as clear as they are in this case. Tentative actions are categorised according to two modes of dairy collection chains in table 3.5.2, illustrated in photo 3.5.1 and they are part of a follow up project currently underway.

Table 3.5.2. Priority actions for different stakeholders in the dairy industry and for the 'chain modes'

	'village milk centre'' with middlemen	*'entrepreneurs''* no middlemen, direct feedback
Recommended action for farmers / local leaders		
General (soft & hard)		
- Training and education; improvement of management in general,	+++	+
- Feedback from the dairy industry (see photo 3.5.1)	+++	+
- redesign dairy colonies, especially with respect to role middlemen	++++	NA
- Awareness of prevention costs and failure costs	++	+++
Specific (hard & soft)		
- improved fodder production and feeding management	+++	++
- attitude and practice of correct milking routines	++++	++
- access to clean water	+++++	++?
- milking machine maintenance and service	+++++	++
- housing conditions, hygiene, climate	+++++	+++
- manure and environmental management	++	++++
Recommended action for universities		
- Setup training programs for farmers,	+++	+
- Research on milk production according to international standards [1])	+++	++
- Research on effective milk payment schemes in China	+++++	++
- Development of animal health control programs	+++++	+++
- Develop Good Agricultural Practices for local conditions [2])	+++++[2])	++
Recommended actions for the industry		
- Introduce payment schemes based on components and milk quality	++++	++
- Introduce rewards (bonuses) and penalties.	+++	+++
- Give feedback to individual farmers.	+++++[3])	++
- Develop and/or introduce appropriate equipment	+++	+++

Notes: 1): can be copied from other countries; 2): needs be designed locally; 3): topic of a project currently underway.

Photo 3.5.1. Methods of feedback and producer mindset are essential to ensure product quality. The California Milk Test is a simple farm level test for producers to directly see the quality of the milk (left). Machine-milking is often assumed to be good for milk quality but that may not be true if done in an unhygienic way which is a mater of attitude rather than technology (centre). The lady on the right is a champion on milk quality [in Brazil], having a cooling tank while still milking by hand (right).

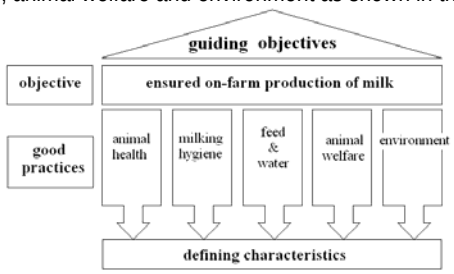
4. Visioning the qualities for the future

4.1. From product to process quality, a matter of policy.

Improved *product quality* is urgent for the general public and the business. Also, it can even lead to higher yields by ensuring healthier cows. Eventually, however, attention to product quality needs be followed by attention to issues of *process quality*, often described in terms of good agricultural practice (GAP). This implies a broader definition of quality, including aspects of animal health, hygiene, use of feed & water, animal welfare and environment (Box 4.1). Design of future systems and chains is done at many places of China and abroad, with more and/or less imagination. This chapter starts by listing hard and soft '*rules of the game*' and '*trends*' for the sector. It then lists complexities, i.e., policy choices [on trade offs] between gains in one part of the chain with losses elsewhere. It concludes with a discussion of core competences in dairy production. Based on that, the next chapter suggests direction for novel, perhaps farfetched but realistic directions for process qualities on the long term.

Box 4.1. Good Agricultural Practices and 'process quality' (based on FIL-IDF and FAO; 2004)

In 2004 IDF and FAO published a general code for Good Dairy Farming Practices. The guiding objective for good dairy farming practice is that milk should be produced from healthy animals under generally accepted conditions. To achieve this, dairy farmers need to apply Good Agricultural Practices (GAP) in the areas of animal health, milking hygiene, animal feeding and water, animal welfare and environment as shown in the diagram below.



Control points must be managed to achieve defined outcomes. For all areas (=columns) specific GAP guide lines were developed, implying that producers keep records, e.g. regarding traceability of agricultural and veterinary chemicals, use of animal feed and identification of individual animals. Records should be kept of milk storage temperatures, veterinary treatments of individual animals and so on. The owner of a large dairy farm should also ensure that people undertaking and supervising the milking operations and management of the dairy farm are (and continue to be) skilled in animal husbandry, hygienic milking of animals, administration of veterinary drugs, activities undertaken on the dairy farm in relation to food safety and food hygiene and health and safety practices relating to dairy farm operators.

Photo 4.1. Sketches of future farm designs by students of Henan Agricultural College (left), by a dairy development scheme in Harbin (centre) and by a combination of stakeholders in The Netherlands (right).

4.2. Hard, soft and complex rules of the game

Potentials for future product- and process quality in China are set by biophysical rules, by imagination and attitude of chain managers and the dynamics of the chain. In short, the future depends on:

- bio-physical aspects that are called *'hard'* rules of the game in this report (Box 3.1). Much variation exists in China in terms of hard-system rules, e.g. some 500 to 19000 kg feed dry matter can be produced per hectare, 2 to 40 lts of milk can be produced per cow, and 20 to2000 litres of water can be needed per litre of milk. This gives scope for increased efficiencies and it also sets limits to what is possible, implying a need to seek 'novel' ways for continued growth.

- attitude and cultural aspects set the 'soft-system' rules of the game that can be more important than 'hard' biophysical ones. For example, producers and middlemen may find it hard to change their attitude to quality, and companies fail to incorporate sustainability issues into business. Also, consumers fail to see that milk with special process-qualities has a special price, while research and teaching find it hard to rediscover mixed farms and cross-bred cows (Photo 5.1), or to redefine goals of dairy away from only milk towards inclusion of issues such as rural development, resource conservation and (re)generation (Ch 5). All this, again, is both problem and opportunity and the next chapter lists some [farfetched but] practical options in this respect.
- business cycles and system dynamics are rather newly acknowledged aspects of sustainability, also called 'complex-system rules'. They reflect issue of trade offs and change, with advantages and disadvantages, requiring tailor made solutions and attention to local priorities.

4.3. Rules of the game as set by trends in society.

The dairy's future is also determined by local and (inter)national level trends (Photos 4.2 and 4.3). Examples of such trends are the change in demand for milk, consumer taste (ready made food), competition, costs of inputs etcetera. They also include issues associated with the notion of process quality, e.g.:

- public awareness on environmental issues may push demand for special process quality, including attention to issues of footprint, environmental quality, animal welfare, and the like. It opens opportunity for products such as organic milk, fair-trade products, free range animals etc.,
- (irrigation) water and fossil fuels are likely to become scarcer and use of irrigated fodder with high fertilizer levels are to be reconsidered, opening a new focus on use of crop residues and cross-bred animals on mixed farms, as well as on farm-designs that save on water and energy.
- biodiversity ranks high on the public agenda, potentially translated into use of local breeds and tailor made development. That may suit urban people that like agro-tourism in which mixed farms and healthy communities offer greater opportunity than specialized farms (Photo 4.3)
- the need for balanced development in terms of a strong producer base and low consumer prices implies re-assessment of potentials in mixed farming and/or shorter chains (Ch. 3.3 and 3.4).
- erosion and sandstorms due to overgrazing are already a public concern, as well as pollution due to intensive and industrial farming systems. Again, this opens a challenge as well as opportunity for the dairy sector, where livestock can play a positive role in range land management and where gains in terms of environmental performance can be made without great effort (Photo 5.2).

Many more changes are around the corner, e.g. related to climate changes, use of biotechnology, use of bio-fuel with associated shifts in availability of starch based feeds and byproducts from bio-ethanol and bio-diesel, etc..

Photo 4.2. Concern about the environment is evident from China and abroad from symptoms such as delayed flights due to sand storms (left), water availability (centre) and notices regarding emerging diseases (right), much of which has to do with [complex-system] issues of scale, rate and degree of processes.

Photo 4.3. Trends in public attitude will sooner or later affect the definition of process quality in dairy of the future. For example, a trend towards agro-tourism is also seen in China (left), as well as the concern about balanced development (centre), and about the tension between affluence and obesity (right).

4.4. Trade offs and cross cutting issues for policy makers.

Thus far we discussed variation between dairy systems on chain aspects such as resource use, feeding, collection and processing. Action was specified for different conditions and parts of the chain, assuming given production systems. In that sense, work on product quality for the short term has the advantage that it needs consider only rather well known variable in well known situations. Work on process quality for long term is less certain but also less bound by short term concerns; chain managers can redesign the chain and/or redefine the goals (Photo 4.1). Design of long term change is, however, also constrained by so-called 'trade-offs' where changes in a part of the system imply change elsewhere. Such tradeoffs are an essence of complexity where everything relates with everything, where systems change constantly and where simple solutions do not exist. It is also the arena of policy choices, where for example:

- work on high tech and capital intensive systems that produce only 20% of the milk may go at the expense of the potentially more efficient producers that supply most of the bulk (Fig. 4.1)
- rigid and well controlled production chains can be efficient but inflexible. Also, uniformity may help to speed up on decisions, but it reduces options for tailor made and efficient solutions.
- large scale farming can produce good milk, and it can be efficient by getting economies of scale, but it tends to be less efficient in ecological terms, i.e. considering resource use efficiencies. Large scale food sheds with large foot-prints and high food-miles imply greater fossil fuel needs for transport with their associated carbon loads.
- higher fertilizer use efficiency may be coupled with high yields, but it may also require more water for irrigation (Fig. 3.2.1), thus potentially resulting in lower water use efficiencies. Typically this shows the need for tailor made approaches since water requirements of milk production are important in arid regions but rather irrelevant in regions with high rainfall.
- emphasis on clean milk with no germs implies a reduced capacity of a population to cope with disease, and processing for hygienic and/or added products implies increased prices with less access of poorer sections of the population to otherwise valuable food.
- demanding consumers require change in milking and /or feeding practice at farm level, indirectly leading to social change with or without social stress among producing communities

Indeed, win-win situations do occur, for example, where gains in milk product quality (e.g. udder health) are accompanied by gains in milk yield and resource use efficiency. But many cases require choices where advantages for one part of a system are disadvantages elsewhere. An example is implied in the four mode quadrant (Fig 4.1). It suggests that 80% of the resources goes to 20% of the production potential on [large] specialized farms. They are supposed to perform better in terms of product-quality, but that is not proven and product quality on small farms can also be improved a lot. The large and specialized farms, however, are likely to perform less well in terms of process quality, e.g. regarding aspects of resource use efficiency, balanced growth, etcetera. The 20/80 ratio is a rough approximation and more work is needed on this issue, but the essence is that much can be gained by seeking a new balance between attention to small mixed farms on the one hand and large specialized farms on the other.

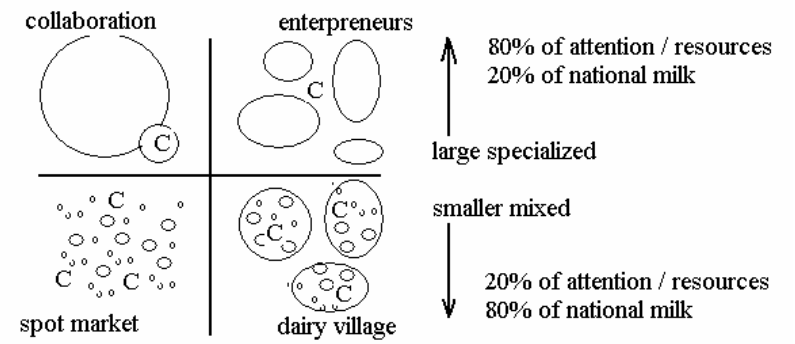


Figure 4.1. The four-quadrant model and implications for policy; suggesting that only some 20% of the milk is produced by large and specialized operations which might receive some 80% of the resources (based on diagrams in Fig. 3.4.1-3.4.3). The 20/80 ratio is an approximation but well known from other sectors of agriculture and society.

4.5. Core competences of dairy for sustainable development.

Last but not least, the future role and shape of dairy chains is determined by the core competences of dairy in terms of environmental change as listed above. Work on the dairy chain offers more opportunities than what seems to be understood in the search for balanced growth, livelihood for rural areas, regeneration of resources, management of ecologies and the like. In that sense, any design of new chains should consider the core competences of dairy, e.g.:

- milk is a high value product with potential for added value at local and national level. Changes in terms of product quality can result in higher yield per animal, but also in development of a large and ecologically more efficient 'mixed farming sector'
- cows are particularly well suited to convert fibrous feeds and by-products from human society into high quality products like milk, meat and draught. Pigs and chickens may better convert grain products, implying choices on feed allocation between sectors.
- the dairy sector can be a flexible pillar of rural development and a good way to shift urban earnings into rural communities. Current policy tends to unduly favor the large enterprises such as of the 'entrepreneur' and 'collaboration' modes.
- dual purpose dairy systems can help regain market share and farm income from the consumption of beef-related meat from young and older animals. By only considering the cow for its milk yield a lot of other potential may be overlooked.
- a multi purpose vision of dairy production can open unexpected opportunities for management of landscapes, resource regeneration, rural development and the like.

The term 'from sink to source' is elaborated in the next chapter to suggest that dairy offers opportunities to generate rather than to cost resources. Mindsets are both problem and opportunity, together with challenges in terms of hard and complex-system rules of the game. Options are discussed in the next chapter to shift into novel directions where the footprint of dairy could change drastically.

5 Future qualities, the practice.

5.1. Default or design, product and process quality.

Dairy chains in China face challenges arising from the growth of the sector itself and from public concern on sustainable development. This chapter illustrates what can be done on the *design* of future systems and chains for improved and sustainable '*process quality*' (Photo 5.1). It assumes that the sector gains more by identifying creative long term options (=design), than by continuing to do more of the same (=default). The design of future systems for process quality could be started through multi-stakeholder workshops using experiences from elsewhere. More elaborate mathematical modelling and scenario planning with 'hard' data for environmental impact assessment, footprint analysis and other calculations would be a next step. A first step in the 'workshops' would be the use of soft system methodology that focuses on mindsets and attitudes (Photo 5.2), to creatively redefine goals and methods in chains, e.g.:

- stakeholders might consider the presumed 'problem' of low product quality in the small and mixed sector (bottom half of the quadrant in fig 4.1) as opportunity in terms of the potential to increase total yield while assuring process quality.
- chain managers might consider dairy farming as a way to also (re)generate resources, rather than to produce milk alone, i.e. shifting from single to multi-purpose. In other words, dairy could be a source rather than a sink of nutrients, water and community life.
- policy setting could decide to consider a shift from standard to tailor made approaches, to optimally use local opportunities and to better solve local problems. Depending on the location one might chose for (a mix of) large and rigid industrial systems, or shorter and more resilient ones.

Design for process quality reflects the notion of people, planet and profit (PPP). This report, however, aims to lift the arguments beyond the sometimes superficial PPP-notions towards realistic options for commercial and rural development. Nevertheless, current PPP programs might take it as core activity to run workshops, think-tanks and R&D for future process quality of which contours are sketched below.

Photo 5.1 Shift of dairy-production from resource *'sink to source'* implies a search for new production methods. That can be use of dual purpose Montbeliard cows as in modern low cost Dutch dairy (=*'lagekostenbedrijf'*) that also generates diversity (left), milk collection systems of small farmers in Brazil to generate 'community' rather than only 'commodity' (centre), and buffaloes in mixed crop livestock systems of tropical regions in China (right).

Photos 5.2 The role of livestock in degradation and/or restoration of the natural resource base, with resp. degraded and restored hills in South America and Africa, a matter of mindset and not of available technologies.

5.2. The dairy chain, from sink to source and beyond people, planet, profit.

The challenges are known in broad outline, together with practical examples of design for the future, based on cases from within China or abroad:

- the priority might be to improve product-quality by redesigning payment / collection schemes, especially of (smaller and mixed) dairy farmers that produce 80% of the milk with perhaps 20% of the resources. Work

has started in 2007 to incorporate dairy producers from the bottom half of the quadrant, ensuring that rural people become a resource rather than a problem.

- re-invent the role of livestock in new crop rotations, soil organic matter management, nitrogen fixation, pests and disease control, use of crop residues, rural tourism, biodiversity and so on. 'Green'- labels are already known in China but more is possible, given the scale and the variation of the country.
- use of dairy for soil conservation and water catchment can ensure that milk 'generates' rather then to cost soil and water, thus becoming source rather than sink (Photo 5.2).
- 'biodiversity' as component of process-quality can be considered an 'environmental service'. And use of native animals for harsh conditions like yaks, sheep and goats is a key to once again make pastoral areas productive, even if grazing systems need to change. Standard approaches with high yielding animals cannot serve a significant role in harsh conditions of mountains and tough climates.
- milk and/or meat could be marketed as traditional and/or modern 'added-value' products through both short and long chains. Starts are made across the country with preferential government policy for buffaloes and local pigs. In that way livestock can become source of local culture and new cropping patterns, also with novel ways to include trees, shrubs and other crops to increase biodiversity (with birds and small wildlife) while supplying feed and fodder.
- a shift from single to multi purpose animals will also help to reassess the calf- and meat production from dairy. In that respect the development of so-called *'pink veal'* in the Netherlands is an interesting case. It combined hard-, soft- and complex system aspects to develop, produce and market a new product with a new process quality,
- problems of nutrient loading are serious but much can be done with little effort (Photo 3.2.2). China starts work on such issues and it can take heart from Dutch dairy farming that reduced fertilizer nitrogen use from > 500 to <250 kg/ha/yr while maintaining yields and improving process quality.

Photo 5.3. Solar energy for heating of animal housing using light roofing panels in Heilongjiang (left), UHT as a probably low footprint product (centre) and new ways of participatory R&D by the Henan Agricultural University (right).

5.3. More options for process quality, from default to design.

Dairy in China is not unique and it can serve as example for other parts of the world. Novel approaches in China exist already (Photo 5.3), but more is around the corner, especially for mindsets prepared to also learn from other sectors (Box 5.1). We thus conclude with examples from the (inter)national scene, even if much is a matter of re-inventing 'old' approaches. Still, some developments are rather groundbreaking, e.g.:

- a strange case of product design for process quality is known already in the form of UHT milk. It has a disputed reputation, among others due to its 'off-taste', but it can serve as example of '*milk of the future*' since it requires no cold storage and refrigerated transport. We did not find, within time and resources available for this report, a study on its environmental impact assessment but we think that it is a product indeed with a different footprint. It also implies a typical feed-forward from producers to consumers where consumers need to change their mind on 'taste of milk' in order to achieve better process quality (Fig 2.1; Box 5.1). The high energy cost of large scale food-sheds (with transport and packaging) is an issue not yet receiving much attention.
- energy cannot be produced, but agriculture can conserve rather than waste energy. Design of animal housing with transparent sheets that allow solar energy to heat buildings in extreme cold winters of the north do help to conserve rather than waste energy (Photo 5.3). Solar energy can also be used to heat water, and biogas is a way to use parts of the organic matter in animal excreta for cooking and lighting. One may assume that biogas is a better way of using crop residues than burning of those residues for generation of electricity (Photo 5.4), leaving the nutrients on the farm. Novel forms of bio-diesel exist that can turn animal excreta into other energy

products than biogas (Photo 5.3). The 'core-competence' of mixed farming in terms of nutrient use efficiency was already mentioned in Ch 3.3.

- many traditional R&D systems use standard- and top down methods, often leading to disappointing results especially in variable conditions. Much experience now exists, around the world and in China, on participatory approaches and teaching for farm design and management, including farmers' experience (Photo 5.5). It creates a win-win situation for official R&D institutions, also because the impact of their work improves and because it helps to quicker identify relevant field problems.
- micro-credit may offer a unique example of a people-planet-profit approach by large dairy companies to counter-balance the role of the middlemen that tend to play a crucial and not very positive role in issues of product and process quality.

Photo 5.4. Competition for crop residues as a source of organic matter and soil fertility, or as fuel for 'clean' energy (left); a Dutch farmer working to develop bio-diesel from pig-manure (centre), and stubbles left un-grazed on purpose to reduce wind-erosion and dust-storms in Southern Australia (right)

Box 5.1. Examples of system redesign from the non livestock sector and elsewhere in the world
The world is full of cases with significant changes towards more sustainable farming. Examples are shown below from other sectors than dairy production, explicitly to stretch the imagination: - greenhouses are notorious 'energy – sinks', costing much fossil energy to control their micro climate. Thanks to novel redesign they can now 'produce' energy in the Netherlands. Energy as a (multiple) goal of the business helped to ensure the sustainability of that sector. - mainstream sewage and farm waste processing tends to be based on aerobic processes that cost energy, but anaerobic processes are now fine-tuned to produce energy on industrial scale in processes that fare even better with less water, thus also saving water at the same time, - a major beer company started to use local sorghum in Africa as raw material for the brewing process (instead of imported barley). The different taste was slowly introduced, a case of adapting consumer-habits for sustainability and balanced development - large scale credit systems are traditionally 'out-of-reach' for small producers, thus maintaining rural communities as problem rather than as resource. But modern micro-credit systems, potentially considered as PPP-activity, might offer opportunities for Chinese dairy to tap into the potential of the bottom half of the mode-quadrant. - urban sprawl pushed farming away from cities and producers away from consumers, thus lengthening the food chain and increasing expenses for transport & quality control. Significant movements exist around the world where a new balance is sought and where consumers and producers are brought together again, e.g. by re-inventing short chains as an opportunity for business rather than as a public health hazard. - environmental degradation with large dust-storms in the central US-plains resulted in the 1920s, among others, from use of cropping patterns and mindsets that required tillage and that left the soil bare for part of the year. Cropping patterns, tillage methods and management practices were changed after the dust-storms, including soft-system aspects such as mindsets that persist till today. - the traditional emphasis on use of annual grain-crops is now getting a new direction, also in the US, from people that seek to find perennial plant-ideotypes which help to restore and maintain soil fertility, among others to avoid nutrient leaching to the gulf of Mexico. - dust-storms in Southern Australia were due to excessive grazing of stubble fields, and sugar cane in the North was burnt to facilitate harvesting of the cane. In both cases both farmers and institutional R&D changed their mindset, eventually leading to a unique farmer-government program for rural development (Landcare).

5.4. Tailor made approaches and implications for chain managers.

Planning and teaching on dairy in China tends to focus on standard, what we call default scenarios. Thus far this implied much attention to use of specialized milk breeds, uniform feeding practices, milking methods and so on. However, design of future systems requires flexible mindsets and tailor approaches to suit and better use the variation

of Chinese dairy chains. Nature works with variation and plenty of practical and theoretical are available to explain the ecological (and long term economic) advantages of variation. Two more examples should serve to –finally- illustrate the essence of tailor made approaches for chain managers:

- regarding production conditions, dairy on scarce land and water resources in the central plains need a different approach than dairy in the Northern steppes or the Southern hills with more land, other climate and different logistics than the central plains.
- regarding logistics and footprints, dairy production and chain management for product quality in distant markets require a different approach than process quality for local development priorities and resource conservation. The notion of local food for local people is rapidly catching on in the world, not in the least due to concerns about high energy use of large scale systems.

Management, administration, teaching and research can take advantage of differences and great changes are possible in that sense.

6. Quality as driver for change in chains, concluding comments

6.1. Main conclusions on product- and process quality.

The rapid change of dairy production systems in China is likely to continue. It is reflected in current change that is already underway (photo 6.1) and it implies change in hard-, soft- and complex (=structural) aspects of the sector. Short term attention to the need for more milk is to be accompanied with attention to aspects of product quality of milk, for reasons of public health and processing for added value. As a unique case of win-win, success in terms of improved product quality is also likely to increase milk yield and to better use the potential of small and often mixed family farms. The long term requires specific attention to process quality as extension of product quality. In that respect the often smaller and mixed farms can play a bigger role than often acknowledged.

Photo 6.1. New approaches and mindsets are emerging to cope with change and variation in Chinese dairy systems, giving more attention to sustainable profit (left), new ways of participatory R&D to suit solutions to local conditions (centre), and public concern for environment and ecology here shown in a newspaper clipping (right).

This report thus identifies four main opportunities for short and long term action on dairy development via the approach of product and process quality, i.e.:

- much can be gained by better managing resource use on the short term, and by exploiting the variation of current production-, collection- and processing systems. For example, feed production across China varies from < 500 to > 25.000 kg dry matter / ha and water use can range from what we call the range of 20 to 2000 ltr water / ltr of milk. Such large variation gives scope to identify more efficient dairy systems, with a larger role for mixed farming systems than often recognised. Many technologies for this are known already, and a clue lies in a shift from standard- to flexible and tailor made approaches.
- the large range of production systems also implies variation in collection and processing 'modes'. Most milk still seems to come from mixed and smaller farms via informal markets, but most of the official attention seems to go to larger specialized systems. Resource efficiency tends to be higher at smaller and mixed than at large and specialised farms, depending on the criteria that are used. Therefore, much commercial, ecological and social opportunity will be gained by also supporting the informal sector that provides much milk in a potentially efficient way, eventually leading to better process quality in terms of balanced development and better resource use
- product quality of milk in terms of bacteriological characteristics and milk composition is both a major short-term concern and opportunity. It is crucial to include majority of producers that contribute up to 80% of the total milk yield of China. It also allows processing and value addition in the chain. The choice for specific chain approaches needs be tailored to desired products, to the respective companies and to the specific farming conditions. For the short term we suggest to take product quality as top priority.
- process quality is the next priority including focus on resource and efficiency, balanced development, biodiversity etc. In that sense dairy production has unique 'core-competences' and if well done dairy becomes a source rather than a sink of resources. A diversified focus on dairy development with both small and mixed as well as large and specialised offers more opportunity for sustainable development than a single focus on large and specialised production alone. Inclusion of cross-bred animals, buffaloes and even yaks represent a potential for the future, provided it goes with associated changes in mindset of business, training and research. Many examples exist in China and other places in the world where dairy production has roles beyond production of milk alone, as source rather than sink.

6.2. From sink to source.

The associated notions of process- and product quality open opportunities for sustainable development of the dairy chains in China and elsewhere. By taking local priorities as a starting point this implies in one region a focus on '*dairy*

as engine for balanced growth', elsewhere dairy can '*regenerate local resources*', becoming '*source rather than sin k of resources*'. Use of dairy to reduce the frequency and severity of dust storms and to replenish water resources is a '*farfetched*' but urgent priority in one place and in other places the re-discovery of mixed farms and adapted breeds can serve the commercial and rural development interests of an industry that needs to produce cheaper, more and better for a demanding market. Milk can eventually be labelled in terms of environmental impact and rural development, a trend that is starting already.

Photo 6.2. Product- and process quality [in dairy production] are two sides of the same coin. They offer opportunities in terms of assured sales through safe products as antibiotic free milk (left), and a variety 'green' and 'low-footprint' systems of which organic is just one example (centre). One of the challenges is now whether and in which way dairy manages to establish its core capacities to regenerate resources in rural development, from sink to source (right).

Dairy has unique 'core capacities' for sustainable development that can need tailor-made approaches for variable conditions. And notions of hard-, soft- and complex system thinking show that opportunities lie in the hardware (technologies and inputs), in the software (mindsets of producers, chain managers, R&D and consumers) and in better understanding of complexities (system dynamics, business cycles, variation, effects of scale). The dairy sector in China stands at crossroad, and it can chose to generate resources rather than to exhaust them, to see poor milk quality and family level producers in rural areas as opportunity rather than as a problem.