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China's Dairy Chains
Towards qualities for the future

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Towards qualities for the future

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December 2007

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 is attached with more examples, background-information and literature-references.
Comments and suggestions are very welcome.

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 attached 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 and Bram Wouters of the WUR, 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 in the Netherlands, Yang Zhengde in Guizhou, Yao Wen in Nanjing and Wageningen, Ma Mei in Beijing, Lu in Wageningen for the final picture of eroded hills in Northern Shaanxi province, as well as 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; December 2007

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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 '*proce*ss 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 (Ch 2.3 – 2.5), and as now done in a follow up project
- 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.

中国乳业链:面向质量的未来

摘　要

中国乳业生产正经历前所未有的变化与发展。这种变化和发展在中国不同区域的农业生态和社会文化条件下表现出一定的差异性。本报告旨在塑造乳品质量的长期与短期可持续发展行动框架。同时，分别从软环境和硬环境两个复杂系统，探讨技术、思维定式、链的动态特征等问题，有意于实现乳业部门的经营和政策、研究和教育的变革。报告基于对中国乳业链，特别是北部、东北部以及南部山区乳业的审视，通过链分析，阐述了中国乳业的变化和差异性，并对产品质量与过程质量提出了对策建议。

目前，针对乳业链产品质量的短期计划主要包括：微生物质量控制、细胞数与乳成分分析，常用的ISO与HACCP质量管理方法的推广等。长期关注的问题则从可持续发展、体现资源利用效率的良好农业操作规程（GAP）等过程质量的角度，加以讨论。诚然，短期良好的产品质量管理将带来产量增长，以及长期资源利用效率的提高。

为辨析中国奶业系统内部在生产方式、资源利用等方面的巨大差别，报告主要从五个方面，对中国乳业生产系统和乳业链的差异性进行了分类，以便量体裁衣，为产业发展创造新的机会。这五个方面分别是：

1、乳品生产地距离城市中心区域的距离（体现在饲料和奶产品价格的差异）；

2、资源的可获得性（体现在北部干旱、寒冷地区与南部潮湿、炎热地区的差异）；

3、乳业生产系统设计（体现在混合生产与专业生产的差异）；

4、乳品收购模式（体现在非正规收购模式与正规收购模式的差异）；

5、质量管理系统（体现在散装奶与质量奶的差异）。

通过对中国奶业生产系统五种差异状况的分析，我们发现混合农场的重要性和有效性在过去并没有得到真实的展现。同时，进一步证明了因地制宜地制定饲料、饲养、保健以及排泄物管理等措施的重要性。按照决策的优先顺序，报告就此提出了以下对策建议：

1、乳业链产品质量管理工作应该区别小规模、非正规，与大规模、正规的生产者和组织者。同时，应该进一步挖掘小规模生产者的潜力；

2、应优先关注短期产品质量管理的推广工作，如HACCP等质量管理措施；

3、中国乳业的进一步发展需要根据生产系统和产业链的特点，加强对策的针对性与创新性；

4、在制定政策过程中，需要在混合生产体系与专业化生产体系之间寻找新的平衡点。在这个过程中，混合农场不仅在提供原料奶、保障奶源供应增长等方面，而且在改进资源利用效率，实现和谐发展等方面作用显著，并展现出巨大潜力。

5、长期发展机会将蕴藏在过程质量管理以及GAP等强调资源利用效率的管理方法中，最终通过“绿色”牛奶等产品标识，使消费者的消费意识得到进一步强化。

综上所述，乳业的短期发展机会仍然在于进一步推广提高奶产量与质量的现有技术；长期机会则蕴藏在融合强调地区差异与优势的过程管理的乳业系统再造过程中。这一方面突出了乳业和谐发展的重要性，另一方面也强调了退化资源恢复与再生的必要性。我们预见在未来的乳品市场上，消费者将为乳品生产造成的环境影响付费。从这个意义上，乳业部门在实现农村的可持续发展方面所具有的独特核心能力仍有待开发。

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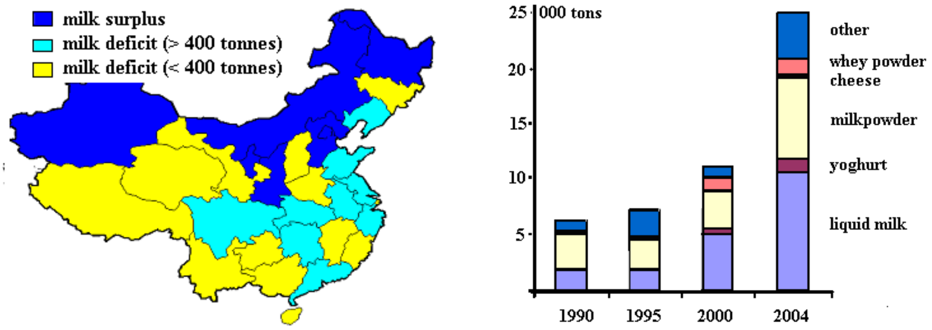
1 Change and variation of dairy in China, an introduction

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 volume quadrupled and product mix changed Towards added value products (Fig. 1.1 and photo 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)

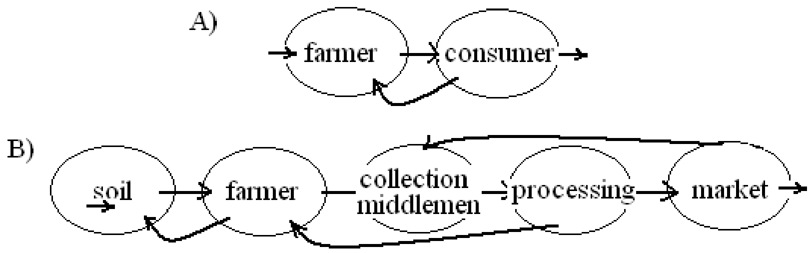
2.3 The chain approach, basics and variations

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 and photo 3.3.2).

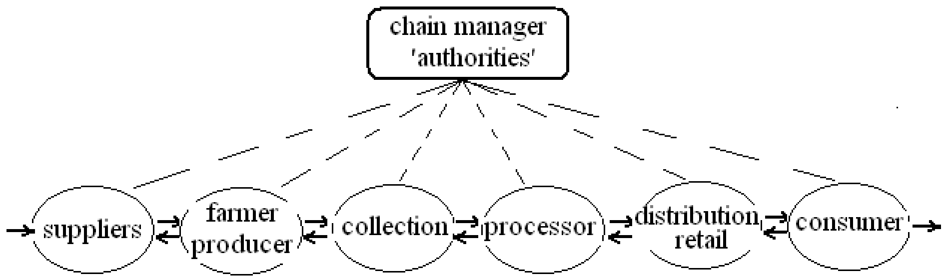
Figure 2.1 The basic models of short and long chains (resp A and B), with feedbacks and feed-forward links



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.

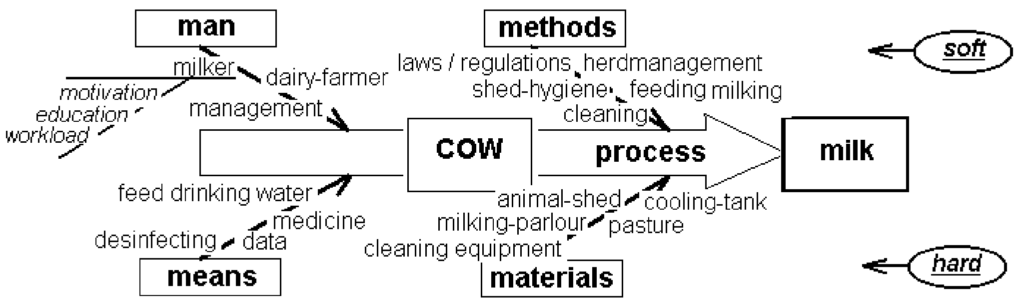
Figure 2.2 The chain based on fig 2.1, with a special place for the 'chain-manager'



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.

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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 3.4.2). Proposed hard- and soft system action for product quality in both categories of table 3.1.2 are identified with the Pareto analysis (of figure 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) direct sales	[Larger] producers far from consumers 2) need for processing
	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 GAP protocols
	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.

Photo 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. 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.

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

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

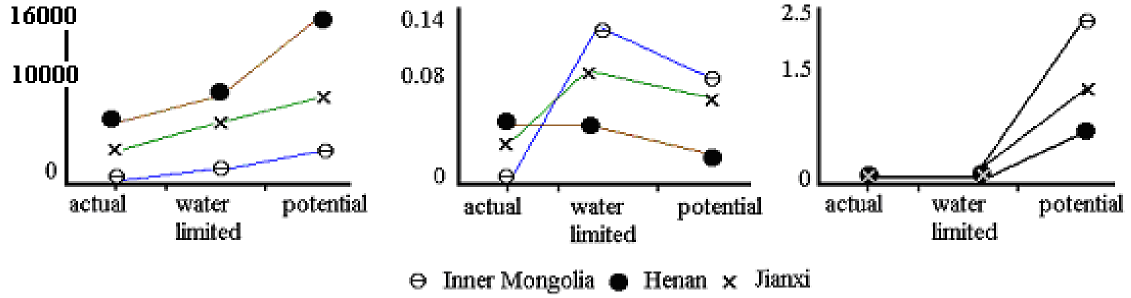


Photo 3.2.2 Opportunities for process quality, in this case nutrient management through better urine-nitrogen collection. Left is a floor in animal housing (Inner Mongolia) that is ill equipped to collect urine. Bad excreta management in Harbin dairy villages is shown in the centre, and grazing tends 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)



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 Specialized 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 specialization 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 3.4.1). Unfortunately, mixed farming is often associated with 'small scale' and specialized 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 specialized 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 specialization 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).
- labor use in mixed systems tends to be higher than in specialized systems, i.e. mixed systems are a labor 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 labor opportunity, thus giving a better process quality than the specialized 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 3.4.3). 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 3.4.3 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.

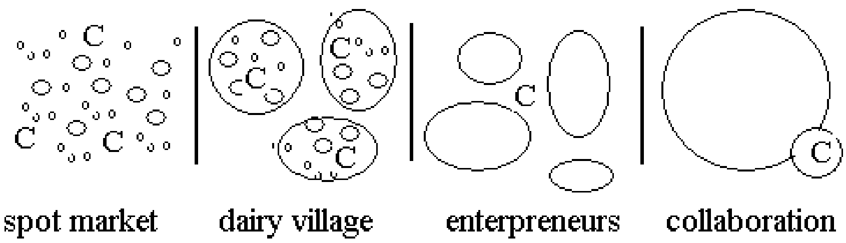
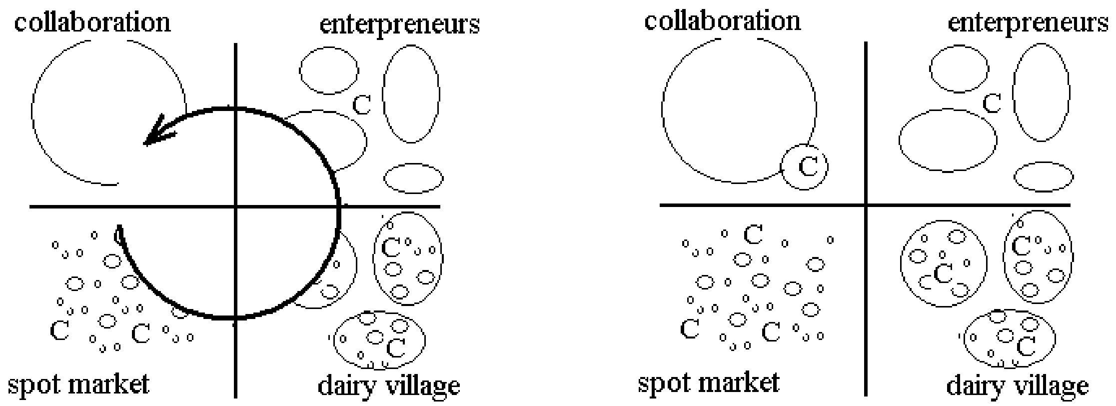


Figure 3.4.2 The four modes arranged in a 'quadrant' with an arrow that suggests progress (left) and more neutrally without the arrow (right)



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

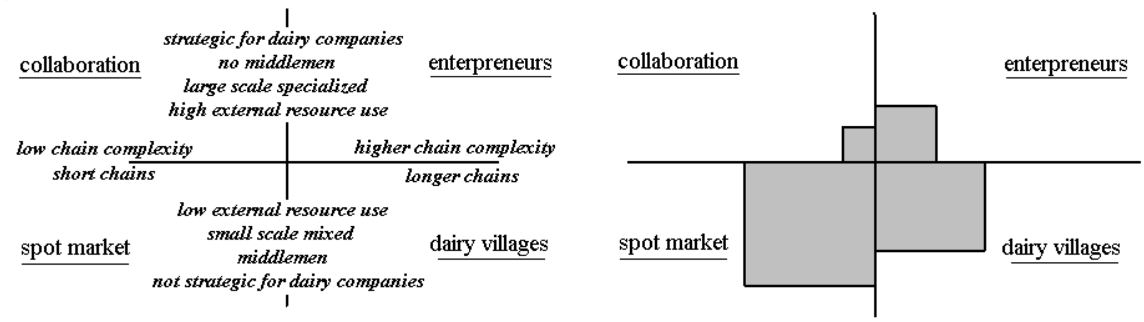


Photo 3.3.2 Cases of dairy farming outside China that again shift into the spot market mode, e.g. a large dairy farm in the USA with 'on farm' sales (left), export quality cheese from on-farm processing in the Netherlands (centre) and an urban dairy farmer in Tokyo with direct sales to consumers (right)

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)

C

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)



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

Specifics	Generally quoted quality figures on milk quality in China (with range)	Allowed according to EU-standards
-Total bacterial counts (TBC) Bacterial colonies/ml	>1.000.000 Often up to 4.000.000	<100.000
-Bulk somatic cell counts (BSC) Cells/ml	>1.000.000 200.000 – 4.900.000	<400.000
-Antibiotics	No data available but generally seen as big problem	Not allowed

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 categorized 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. (for more information contact kees.dekoning@wur.nl)

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	++	NA
middlemen		+++
- 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	+++++[2)]	++
- Develop Good Agricultural Practices for local conditions [2)]		
Recommended actions for the industry		
- Introduce payment schemes based on components and	++++	++
milk quality	+++	+++
- Introduce rewards (bonuses) and penalties.	+++++[3)]	++
- Give feedback to individual farmers.	+++	+++
- 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)

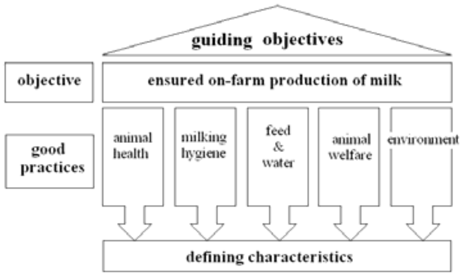
4 Visioning the qualities for the future

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'

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 for example 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.

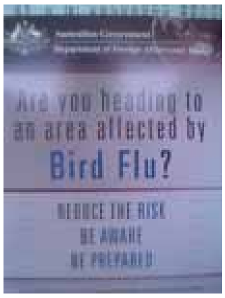
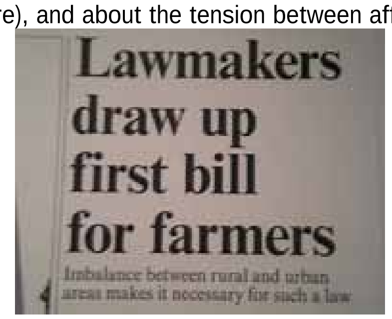
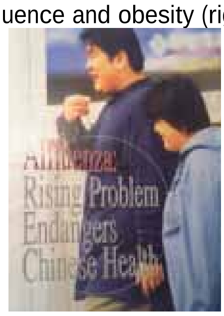


Photo 4.3 Trends in public attitude will sooner or later affect the definition of process quality in dairy of the future. For example, a trend towards agro-tourism is also seen in China (left), as well as the concern about balanced development (centre), and about the tension between affluence and obesity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





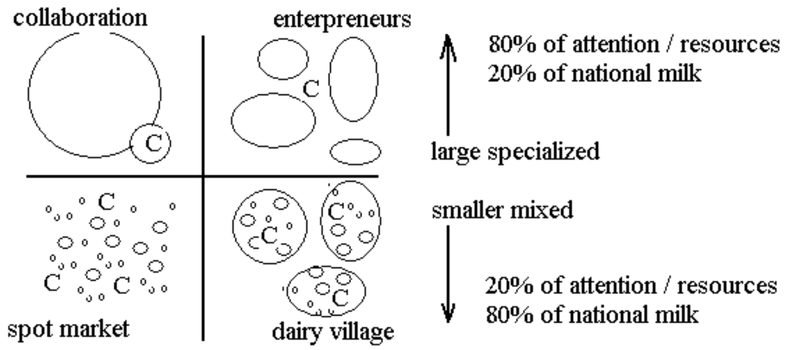
4.4 Trade offs and cross cutting issues for policy makers

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 it is well known also 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.

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5 Future qualities, the practice

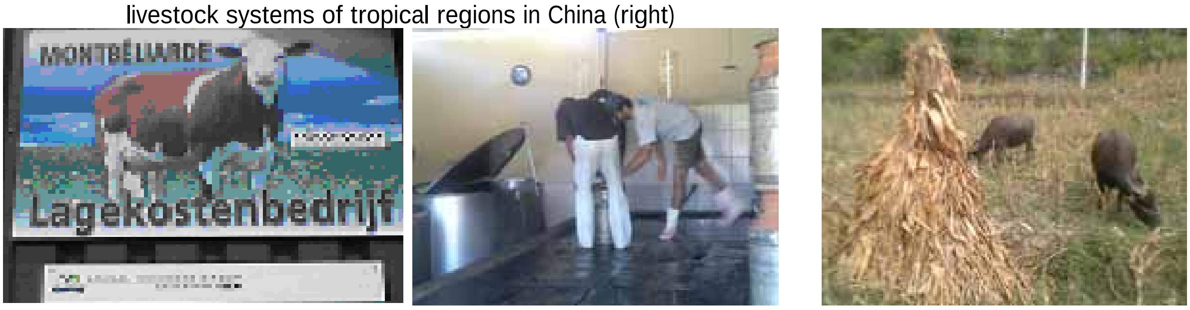
5.1 Default or design, product and process quality

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 specialized 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 specialized offers more opportunity for sustainable development than a single focus on large and specialized 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 sink 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 labeled in terms of environmental impact and rural development, a trend that is starting already. (photo 6.2)

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.

Annex with background information

This section provides backgrounds and examples on the arguments in the main document. The report is discussed chapter wise, concluding with a list of references and suggested reading. Many arguments are left for further elaboration since *this report aims to discuss unknown futures rather than to repeat well-known statements about the past*. Therefore, any comments continue to be welcome, and the authors look forward to continue dialogue on methodology as well as contents.

1 Change and variation of dairy in China, an introduction

More background on change in Chinese agriculture and dairy is available, for example in Gorissen & Vermeer (1985), Simpson *et al.* (1994), Verburg & Van Keulen (1999), Zhang (2001), Wattiaux *et al.* (2002), Wolf *et al.* (2003), Donceva *et al.* (2004), Sijtsma (2004), DAC (2006), Fang *et al.* (undated), RABO (2006), Shi & Zhang (2006), BODC (2006).

More information on change in international (dairy) development and demand patterns can be found in for example Conway & Barbier (1990), Steinfeld *et al.* (1996), De Haan *et al.* (1997), Delgado, *et al.* (1999), FAS (2001), Millstone & Lang (2003); RABO (2004), Steinfeld *et al.* (2006), Beghin (2006), IDF (2007).

The choice of data in this report depends on their relevance and reliability. Overall quality and relevance of data on agricultural change development is doubtful, also in China (FAS, 2001 and Peverelli, 2005). Data on economics and yields that are valid for the East of China are often misleading for the West. But also the relevance and reliability of data for specialized and mixed farming differ considerably, even if collected in one district or when applying to two neighbors. This is one reason why this report chose to use hypothetical data based on real-life information. That also helps to stretch the imagination and the related point on how to make sense out of variation is discussed in Ch.3 of the main report.

The tension between '*standard approaches vs. tailor made*' is crucial in this report, and tailor made is seen as opportunity rather than as problem. *Standard* approaches can help to facilitate administration and planning of development. But considerable market opportunity is formed, even if only a small percentage of the farm population in a large country like China is served through tailor made approaches. Also the market itself uses variation, and it is often the variation of rare products that make the highest prices. In addition, tailor made approaches are a matter of common sense, directly affecting the way in which agricultural R&D should be structured (Van Der Ploeg & Long, 1994). The choice for tailor made or standard approaches has to do with issues of scale, and (dis)economies of scale (Ch. 4). They have to do to a great extent with the emergence of supermarket chains with their own advantages and disadvantages (Hu *et al.*, undated; dinghuanhu@vip.sohu.com).

Practical examples exist where [modified] local systems seize market niches over standard products. The text in box I.1 and I.2 refers to a) a '*modern system of traditional* pig production in the Mediterranean, and b) an argument on advantages of smaller scale from the meat industry in western Europe. For China the case of yak- and buffalo milk might be a potentially strong product in a niche market (see also Ch. 4). For more information contact the main author Hans Schiere of this section at info@laventana.nl.

Box I.1. A niche for a 'modern-traditional' livestock systems in Mediterranean Europe (based on Larovere, 1998)
The 'unimproved-Iberian' pig and the interaction of commercial production with local 'Dehesa' farming form a successful traditional product in regions of Spain and Portugal. The semi-arid climate, low soil fertility, prevalence of oak and cork trees are system drivers, combined with low population densities, traditional pastoralism and poor infrastructure. The 'unimproved' pig retained traits like adaptability to difficult environments, the distinctive taste of its meat and its active behavior. The pigs roams freely and feed on natural resources, like grass and acorns of cork trees. It drinks from ponds and streams, receives minimal care and no feed supplements. The institutions that support this typical crop-livestock system are the regional governments. The system helped the region, labeled a 'less-favored' area within the EU to develop in an 'endogenous' way, and efforts are made to implement conservation policies towards sustainable exploitation of its natural ecosystem functions. A modern variant is to breed the Iberian pigs semi-intensively and to introduce the pigs into the cork oak grazing for the last 3 months before slaughter in October-January. The system benefited from the 'environmentally friendly' origin of its products. Producers learned to improve their label for quality meat, to partially justify their high price. Limited markets, scarce promotion outside the national borders, and relatively high prices so far prevented intensified production, but the system is picking up. The success of this system did not so much result from planning that aimed at realization of specific goals, but it was attained almost 'accidentally'. Local producers and governments have not too easily abandoned a traditional activity in favor of modern specialization and for realizing the important role of this system in sustainable natural resources management. This represents a success because it was left alone, or at least not pressured into change for '*the sake of development*'.

Box I.2. The case for small and large scale in the meat industry (based on Harris, 2004) [2]
[..] The consumer will still want the variety, wholesomeness, safety and traceability, but he or she will also want quality [..] at the same price. This is where smaller niche market producers are likely to score best. These processors concentrating on traditional products whether they are organic, health food, regional specialties or plain honest foodstuffs should be able to gain a marketing advantage over the large manufacturers. Their branding can score heavily in the marketing stakes. It is interesting to see how [..] trends [in the food production chain and distribution industries] run in cycles. Not long ago in the UK, as the supermarkets gained in prominence, traditional butchers' shops started to close. The rise of the supermarket has meant that the number of butchers' shops has halved in about 10 years. All that is left are the niche markets strong trading butchers. Similar trends are being seen across northern Europe. The supermarkets started demanding centrally packed meat products and the butchers that had transferred from the butchers' shops to the back room packing of the supermarkets were no longer needed. However, recently supermarkets have realized that customers liked to talk to the butcher and being served. Now butchery departments are opening up in the supermarkets and the supermarkets are having to train butchers again. A similar cycle could happen in the processing industry [..]. In Europe, with official special recognition for products produced in particular regions, such as Parma Ham or Scotch Beef or Welsh Lamb, the call for niche markets appears to be growing. How long will it then be before the large companies that have grown by buying up smaller ones will start to break themselves up into niche market operators? While the companies might not completely fragment, it is possible that autonomous smaller operations will start to appear under the umbrella of the larger corporation.

[2] based on an editorial that was written for marketing of meat in western food markets but it also touches on many issues relevant for this report: a) the aspects of process quality, and b) the notion of system running in cycles (the drive behind our search for dynamics in section 3.4 and fig 3.4.1-3.4.3 of the main report)

2 Qualities and dairy chains

Many chain and system approaches are known around the world and in China. Cases of Chinese work on food safety and the [dairy] chains are described, for example by Hu (2004), Hu *et al.* (undated), Zhang (2001 & 2005), Zhang *et al.* (2006 & 2007) and Lu (2007). The chain approach is elaborated here to explain the basics of the approach in this report. In reality there is great variation of approaches, all based on use of system analysis to facilitate discussion. Examples of other chain approaches implied in this report are the cyclical chain used of the analysis of nutrient flows on farm (fig I.4), more efficient use of water in agriculture (Huibers & Van Lier, 2005) and the use in management of businesses problems (Peverelli, 2005).

The distinction between product quality and process quality in this report serves to clarify the arguments. It combines with a distinction of [product quality for the] short term and [process quality for the] long term. In reality there is no clear distinction, but for simplification it can be said that methods such as HACCP are primarily used for the product quality on short term, and especially in industrial systems. Methods like Good Agricultural Practice tends to focus on long term issues. They are also more difficult to implement, particularly in what is called the unorganized sector[3].

The definition of 'chain' (链) in China is similar as used in this report, focusing on integration of management in agricultural development. Chinese literature treats the 'chain' as rather static[4] （静态）compared with the more dynamic concept of （动态） in agribusiness and as tool for agricultural development.

(农业产业链则是静态概念。 侧重如何使农业发展不偏离方向，强调的是手段).

The development of the supermarket has rapidly transformed the traditional dairy industry in China, promoting uniformed dairy markets, and creating favorable conditions for transportation of milk from the pastoral regions in the West to the urban regions in the East while also shifting to large scale processing. It replaced traditional retail systems and distribution models of animal products, and its impact on the producers and consumers is enormous (Hu *et al.*, undated; dinghuanhu@vip.sohu.com).

Much quality management in Chinese agriculture still focuses on the short term and quality assurance system such as HACCP and ISO system are implemented only in large farms. Long term approaches such as Good Agricultural Practice (GAP) are still less applied. Still, China does distinguish between product and process quality, e.g. by labeling. The label of 'QS' (Quality and Safety) is treated as compulsory, a way of the government to guarantee food product quality, and HACCP and ISO are the main ways for assuring process quality

The distinction of hard, soft and complex systems in this report can be replaced by many other forms of system approaches, including the one of agro-ecology (Altieri, 2002). Here we introduce the notions of hard, soft and complex to address issues of traditional 'hard' measures like milk yield, water use and cash flows, 'soft' aspects such as mindsets and attitudes to farming, and 'complex' issues such as system structure like scale, resilience, stability (see Schiere *et al.*, 2004; Lopez Ridaura, 2005 and Kok *et al.*, 2006). In Chinese economic development a soft constraint （软约束）of management refers to moral constraints focusing on self-restriction and company culture. Hard constraints （硬约束）refer to regulation and institution constraints focusing on the restriction from outside. (硬约束是指制度约束， 即政策法规约束， 是一种外在的他律；

而软约束包括道德规范的约束， 是一种内在的自律。)

The chain manager in this report is assumed to be the government. We are well aware, however, of other players in this field. Dairy companies themselves have a big role, but middlemen play perhaps the largest role by handling large proportions of the total milk. A middlemen is here defined as the [private] person between producers and processors, often handling the milking operation in shared milking parlors. Examples are known of good practices by middlemen, but rumors about bad management tend to abound. This large role of the middlemen can be seen as problem, but also as an opportunity. In fact, if well engaged the middlemen might be very useful to quickly gain a lot. Around the world it is known that mere elimination of middlemen is a cure worse than disease.

More information about different system- and chain approaches is given by Bawden (1981), Chambers *et al.* (1989), Röling (1996), Ison *et al.* (1997), Checkland (1999), Jackson (2000), Schiere *et al.*, (2004), Peverelli (2005) and Ruben *et al.* (2007). Work on good agricultural practices in dairy (GAP) is documented by FAO and IDF (FAO, 2004) (see ch. 5).

[3] The notion of an 'unorganized' sector ignores that the sector can be very well organized, albeit in an informal way that is often not well understood by planners and outside observers.

[4] [1] " " 2002(5)

[2] " " 2003(4)

[3] 王凯 等（著）：《中国农业产业链管理的理论与实践研究》，中国农业出版社，2004.4

3 Variation in Chinese dairy, five cases

This report uses a large variation of divergent cases to understand how systems change over time and space. The basic assumption is that Chinese dairy is too large to be treated as a homogenous entity, and tailor made approaches can better reach farmers. This is a strange but relevant contrast in development, i.e., a large group can only be reached by diversifying the message. Western approaches to make sense out of variation were already known in ancient Chinese thinking. For example, the term '通变致久' (=change to attain permanence) shows ancient Chinese philosophy about the origin of variation which more focuses on the driving and balance of the system instead of innovation (for more info contact Huashu Wang; amewhs@hotmail.com).

3.1 Variation and distance to consumers (Case I)

The early work of Von Thünen of around 1850 in Germany was forerunner in this sense. His 'location theory' showed how distance to a city determines the farming system. This theme was later elaborated for change in time by people like Rosscher, as forerunner of subsequent 'stage'-theories in development (Rostov, 1960; Nou, 1967). The case in table 3 is based on work near Nairobi (see Owango *et al.*, 1998 and Schiere *et al.*, 2006). It is found around the world, also in China (Hu *et al.*; undated ; dinghuanhu@vip.sohu.com) and in this particular case of dairy systems around Zhengzhou as elaborated during a workshop in 2006. (for more information contact Hans Schiere; info@laventana.nl).

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

The data used here are based on modeling work by Dong *et al.* (2006), Wu *et al.* (2006 and 2008). That type of work helps to predict the yields under various conditions, and it needs testing in the field. However, data based on theoretical models are generally not much off the mark, depending on local rainfall etc., and on ways in which they are incorporated in the model. Biomass yields of for example 350 kg dm/day/ha is high but possible. Remember, however, that in this case they refer to theoretical maximum yields in optimum conditions. For more information contact the main author Huib Hengsdijk of this section at huib.hengsdijk@wur.nl.

3.3 From mixed to specialized (Case III)

Mixed farming provides a large part of the world food supply, often more efficiently than high-tech farms. But mixed farming exists in a variety of forms so some them are not necessarily as efficient as suggested in this report. For more general information on forms and processing in mixed farming, see for example Mureithi *et al.* (1995), Devendra & Sevilla (1995), Devendra (1997), Ho & Chan (1998), Oomen *et al.*, (1998), Sumberg (1998), Conroy & Paterson (2000), Slingerland (2001), Schiere & Kater (2001), Parthasarathy *et al.* (2005), Schiere *et al.* (2006) and Wolfe (in press).

Efficiency of resource use implies a choice of criteria to be used, especially in mixed farming. For example, economic data for the short term are different than for the long term, and labor income may be lower for smaller mixed farms than for large specialized ones, while rural economy and society may benefit more from mixed than from specialized farming. Some of these are hard system criteria (milk yield, cash flow), some are soft criteria (mindset), still others are complex (resilience, stability etc.). For more information see Conway (1987), De Wit *et al.* (1988), Traxler & Byerlee (1993) and Vereijken (1997).

This report refers to mixed farms as integrated systems, and the main point is that these systems can use much less water and other resources than specialized systems because of recycling. For example, feeding of crop residues requires no extra water to produce feed biomass, and re-use of animal excreta saves fossil fuel to produce fertilizer. However, integration also implies a different mindset in R&D, e.g. choice for mutually compatible systems (i.e. crossbred cows for use of crop residues) and attention to the output of the whole rather than the individual parts of the system (Patil *et al.*, 1993; Schiere *et al.*, 2006). Also, integration tends to imply more interdependence / inflexibility. At the same time, a healthy countryside based on diverse types of farming serves as a safety-net for the national economy and -politics because a collapse of urban business and society can drag the whole country down if rural areas are neglected (see the case of Argentina a decade ago).

The cases here represent mixed and integrated farms with special attention to farming in low potential areas (see also box I.3). But also high input systems start to recognize the advantages of mixing, e.g. Van De Ven (1996), Lantinga & Van Laar (1997), Blackburn (1998), Bos (2002), van Keulen & Schiere (2004), Fang *et al.* (undated), Wolfe (in press). Special attention is needed for the choice between use of crop residues for feed, fuel or fertilizer on which much work was done already many years ago (Staniforth, 1982; Sundstol & Owen, 1984; Owen & Jayasurya, 1989; Schiere *et al.*, 1989).

Box I.3. Mixed farming in China (based on Dong, 2003)
Rangeland constitutes 41% of China's total territory, contributing some 1/3 of beef and lamb production and around 30% of milk yields. That is remarkably high considering the harsh and extensive conditions under which livestock is kept and it stresses the need to use multiple rather than single criteria. Also, rangeland management is important to control environmental issues like dust-storms in the northern regions, as well as poverty and issues of local community health. Current crop-based livestock production systems are characteristic of cattle and sheep farming in most agricultural areas of China. Introduced pure beef cattle and cross-breeds with local Chinese yellow cattle are kept at household levels for meat production. Local and improved breeds of sheep are raised at small scale farms for wool production. Animals are mostly fed straw as roughage and agricultural by-products like wheat bran and rape cake as concentrate supplements. Roughly 0.76 billion Mt straw is produced in China annually and half is used as roughage by ruminants. The semi-arid areas in the south-east edge of Inner Mongolia Plateau and the northern Loess Plateau are the so-called transition zone between the pastoral and cropping areas. It is a potential livestock production base where animals, purchased at low price from pastoral areas, can be fed on low value straws and crop by-products imported from cropping areas. Crop by-products are also used to supplement grazing animals like Mongolian cattle and yaks during harsh winter seasons, even in pure pastoral areas like the Inner Mongolia and Qinghai-Tibetan Plateaus. Conversely, livestock in those areas can benefit crop farming, particularly by providing draught power for plowing and manure supply.

Particularly for small and medium farmers in China the yak or buffalo have multiple functions such as to improve farmers' livelihood, as tool for cropping and transportation, typically in the mountainous areas (Dong *et al.*, 2003). Second, the milk of yak and buffalo in low input systems helps improve the nutritional status for the vulnerable members of the farm household, like elderly and children. Third, they are an important saving in farm households, to mitigate financial stress from crises, like disease [in the family] and natural calamity. For more information on multiple goals of livestock and mixed farming contact Hans Schiere, the main author of this section at info@laventana.nl)

3.4 Milk collection structures of the chain (Case IV)

The classification in this section is based on the theoretical work by Peterson *et al.* (2001) who distinguish five columns. The four columns used here appear to better suit Chinese conditions. And by looking for system dynamics along the lines of the argument by Harris (2004) in box I.2 we toyed with the place and location of the columns in figure 3.4.1. That led to the interesting four quadrant scheme of fig. 3.4.2, 3.4.3 and 3.4.2, the main theme for this report. For more information and suggestions contact the main author of this section (xiaoyong.zhang@wur.nl)

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

Product quality is one of the hottest issues in Chinese dairy, both for the farmers themselves and for the processing industry. First, milk quality relates directly with milk yield (fig I.1) and second, quality milk is required for processing into added value products.

However, technology alone (hard system aspects) is not enough for progress in the field of milk product-quality and mindset issues (soft system aspects) are equally important. Contrary to much popular opinion a small farmer can even produce cleaner milk than large scale mechanized ones as shown in cases from India, Brasil and many other countries (foto 3.5.1 right).

The basic approaches are via payment and better quality testing on the one hand (especially with larger mechanized farms) and awareness and internal control on the other (especially for smaller and mixed farmers). The middlemen is crucial, and can be a problem as well as an opportunity. For more information, also on more recent pilot projects in the field of milk product quality in China contact the main author Kees de Koning of this section kees.dekoning @wur.nl)

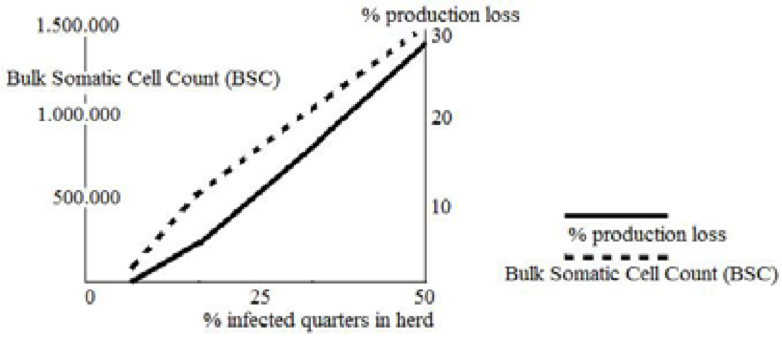


Fig. I.1. The relation between bulk somatic cell count and milk yield (based on Eberhart et al, 1982)

4 Visioning and qualities for the future

Our work on process quality for the long term was based, among others, on scenarios (=visions) where the sector aims for a development that balances demand for produce and management of scarce resources. The resources include both hard and soft aspects, such as prices, yields and nitrogen on the one hand and skills and social balance on the other. The rules of the game in this report refer to well-known aspects such as maximum biomass yield, economic parameters, nutrient cycles and excreta management.

We assume that global and national problems of rapid industrialization, Rio, Kyoto etc are well enough known[5] for people from production (Nell, 1998; Steinfeld *et al.*, 2006) as well as for people of the processing industry in China (Anon, 2004; Shi & Zhang, 2006). Also we think that enough is known on the effect of feeding on product and process quality (see Tamminga 1996), as well as on breeding (FAO, 2007), health (Slingenberg *et al.*, 2004[6]), CO_2-sequestration ('t Mannetje *et al*, 2007), etcetera. Some of that is elaborated later in this chapter. We suggest that major impact can be achieved by work on scenarios to orient disciplinary priorities.

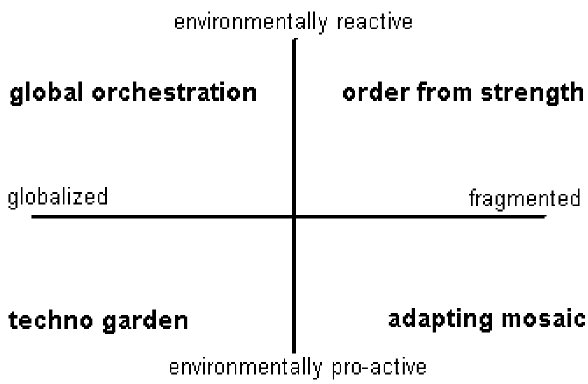
A good example of scenario studies is available from unpublished work by the International Food Policy Research Institute (IFPRI), based on Mark Rosegrant (pers. comm., 2006). The quadrant in figure I.2 shows scenarios that help to understand implications of policy decisions, elaborated in table I.1. They reflect choice between pro-active vs. reactive approaches on environmental issues, and between continued 'globalization' versus 'fragmentation'. They also illustrate:

the use of different scenarios instead of one only, posing choices with their consequences

a choice for *design* rather than *default*, i.e. a choice between where we want to go rather than where do we think that we will go.

The quadrant is developed for use at global level, but it servs our discussions on change in Chinese dairy. We took two of the four scenarios to describe the state and visions of the systems. They are opposing trends that are *end of pipe* (global orchestration on the one hand) vs *local scale and cautious* (adaptive mosaic) on the other. Our suggested priorities and issues are based on expert opinion, not on long and in-depth study. They aim to stimulate discussion rather than to give final conclusions.

Fig. I.2. The quadrant with policy scenarios designed by IFPRI (based on Rosegrant, per. comm.. 2006)



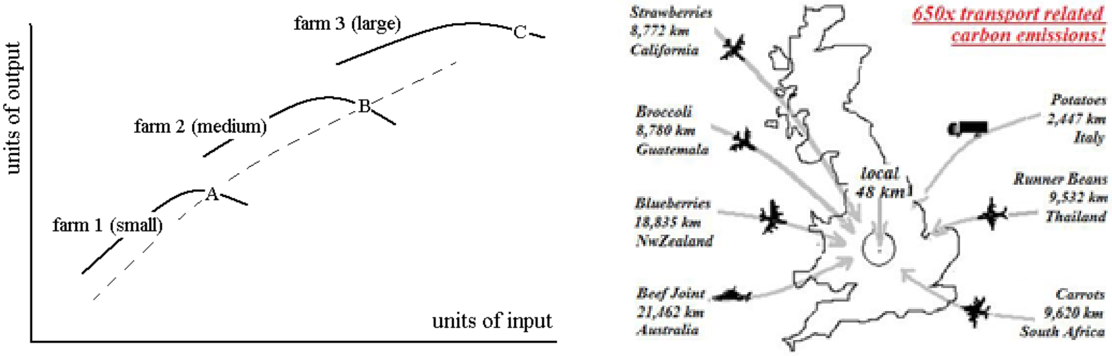
[5] See for example http://www.un.org/esa/sustdev/documents/agreed.htm
[6] See also http://www.bai.ph/eahmi/default.html

Table I.1. The IFPRI scenarios specified in terms of development-, economic- and social approaches (based on Rosegrant, 2006; IFPRI; pers. comm.)

Development approach	Economic approach	Foci Social policy
Global Orchestration: Focus on macro scale policy reform for environmental sustainability		
Create demand for environmental protection via economic growth and social improvements; public goods	Redefine public and private sector roles; improving markets; trade liberalisation; focus on global public good	Increase global equity; public health; global education
Techno Garden; emphasis on development of technologies to substitute for ecosystem services		
Green technology, eco-efficiency, tradable ecological property rights	Global reduction tariffs, fairly free movement of goods, capital and people, global markets in ecological property	Improving individual and community technical expertise; policies follow opportunities; competition
Adapting Mosaic; retreat from global institutions, focus on strengthened local institutions and local learning		
Learn via management & monitoring, shared management responsibility, adjust governance to resource use, common-property institutions	Focus on local development ; trade rules allow local flexibility / interpretation; local non market rights	Local communities linked to global communities; local equity
Order from Strength; retreat from global institutions, focus on national regulation and protectionism		
Reactive problem-solving by individual nations; sector approaches, creation of parks and protected reserves	Rational trade blocs, mercantilism, self sufficiency	Security and protection

The choice between *tailor-made* and *standard* approaches' reflects differences between *adaptive mosaic* vs. *global orchestration* scenarios, between *more* vs. *less* concern on resource use, and between *ecological* vs. *economic* optimization. One-sided attention for economies of [large] scale tends to overlook opportunities for local differences, just like it tends to neglect dis-economies of scale (Van Zijl *et al.*, 1995; Picamarro, 2002.; Case & Fair, 2002). Arguments on disadvantages of scale are blurred by wrong interpretation of economic data (fig. I.3). They also tend to overlook the costs of fuel (=CO_2 emissions), and they tend to confuse economic and ecological efficiency, i.e. the tension between individual and community interest.

Fig. I.3. Deriving a false production function from inter-farm comparisons (Britton & Hill, 1975; left) and carbon-related externalities of large scale food-sheds (Halweil, 2002; right). The 'traditional' Sunday meal in England made from imported ingredients generates nearly 650 times the transport related carbon emissions than the same meal made from locally grown ingredients (almost 38 vs. 0.058 kg of CO_2!).



- Global trends are perhaps less known than local ones, but on the long term they may be more important than the local trends when discussing choices for process quality. Some such global and local trends are listed here, in rather haphazard order and without trying to be comprehensive, but referring to recent literature[7]:
- energy use is expanding, also in China, and in a world where oil-prices hit the 100$ mark per barrel. China is already a global leader in renewable energy, ranking first in solar heating and small hydropower, third in solar power manufacturing and fifth in wind power. However, China may also overtake the US as

[7] The trends and changes are similar around the world, a typical aspect of complex system behavior. It means that other countries can learn from Chinese developments and vice versa.

top emitter of greenhouse gases. The need for cleaner, more secure and sustainable energy has never been more important (Martinot & Li, 2007). This implies need to redesign agricultural systems, and large scale standard systems of the global orchestra scenarios are likely to be at a disadvantage in this respect

- urbanization, changing lifestyles and critical consumers add urgency to the need to re-design systems for better use of resources like energy and water. They also stress the need to supply more and better food in terms of product and process quality. As the process goes it tends towards global orchestra, since close to 50% of the population now starts to live in cities around the globe, with increased demand for animal products and changing overall food patterns. Different forms of urban agriculture and consumer – producer relations towards the adaptive mosaic are now known from work such as by Schiere & Van der Hoek (2001), Halweil (2002) and Van Veenhuizen *et al.* (2006). Some 50% of China's dairy production takes place in city districts and/or the surrounding sub-urban counties of China's major cities, coupled with growing water use in urban centres, competing with water availability for farming (Ma *et al.*, 2007). Information on water use is available, e.g. from Pimentel & Pimentel (1996), Pimentel *et al.* (1997), Brown & Halweil (1998), Pimentel (2004), , Webster & Ti (2004), Postel (2003 / 2005) and Molden (2007). Work on water recycling and urbanisation can be found in Gardner (1997), Monroy *et al.* (2000), Wolf *et al.* (2003), Huibers & Van Lier (2005), and via other farming methods from Ding *et al.* (2004)[8].
- increasing cost of fuel for the manufacture of fertilizers requires attention to recycling and use of other cropping patterns. Perhaps that is towards the mosaic, (=more diversity), including nitrogen-fixing fodders and elements of agro-forestry systems. Nutrient management is crucial in this respect and it can be done at regional as well as local level. (Fang *et al.*, undated; Gerber *et al.*, 2005). The possibility to save energy in these systems lies in a trend towards adaptive mosaic scenarios, away from global orchestra. Spectacular approaches for energy saving available from the work on Dutch greenhouses that become net-generators (*source of energy*) rather than users (*sink of energy*) as described by De Zwart (1996), Bot *et al.* (2004), Medema (2006), Rosa (2006) and de Zwart & Kempkes (2007). Similar approaches exist from the field of water [re-use] as shown by Càceres Villanueve *et al.* (2003). The shift from sink (=resource use) to source (=resource generation) is elaborated for dairy systems in China, also again reflecting a shift from global orchestra to adaptive mosaic scenarios. The use of fossil fuel related with transport and logistics (fig ..) is thus shown to be important, also with respect to process quality, e.g. in terms of footprint and food-miles (Pimentel & Pimentel, 1996; Halweil, 2002; Wackernagel *et al.*, 2002; Pimentel, 2004 and Pretty *et al.*, 2005;). New visions on food process quality increasingly include such issues of footprint and food quality, energy- and water use (Millstone & Lang, 2003), again reflecting a need for a new balance between global orchestra and adaptive mosaic.
- The tension (=trade off) between energy use and distance is only one of the many tensions in development as stressed in complex system theory. It is also present in the contradiction between the trend to over-eating and poverty. Indeed, obesity and good nutrition are directly related with changing food patterns and life styles, also in China (Zhang *et al.,* in press; Millstone & Lang, 2003; MacRae *et al.*, 2004 and Li Yanping, 2007). Concerns on poverty and the balance between urban and rural development contrast strangely with the concerns on obesity, and they receive increasing attention for political and social reasons (Thornton *et al.*, 2002; Owen *et al.*, 2005 and Lucy Maarsse (pers. comm., 2007).

More trends in livestock production exist with respect to process quality and GAP, including trade-offs such as:

- attention to animal welfare, with implications for cost price, animal management and marketing, but also with opportunities (Appleby, 2005; Grandin, 2003 & 2005). According to research in Guizhou province (September 2007) some private livestock farms have already adapted new breeding and feeding technologies which improve the animal welfare and environment through cleaning and less smelling farming system[9]
- organic farming gets more attention (Scialabba & Hattam, 2002; Giovannucci *et al.* (2005); also in China (consult aiwastar@163bj.com and www.chinaeol.net/cesdrrc). It is often claimed to be expensive and unable to feed the world, but that is a matter of mindset as much as of facts. (for more information contact Hans Schiere at info@laventana.nl)

[8] see also www.iwmi.cgiar.org/assessment/ and www.partnersvoorwater.nl

[9]more info: prof. Jun Bao (jbao@neau.edu.cn) of NEAU; Harbin; amewhs@hotmail.com; www.wspa.org

- emerging diseases like Avian Influenza in poultry do not [yet] occur so much in dairy. That may be a matter of time, however, in relation with agro-ecological conditions and interesting work on this is done by for example David Bourn and associates in the Philippines[10] and Slingenbergh *et al.* (2004).
- biodiversity mostly refers to preservation / introduction of rare breeds, perhaps via use of crossbreeding (FAO, 2007; also in Chinese; Yang Hongjie; yanghj67@yahoo.com). But good use of biodiversity is also associated with improved resource use efficiency and waste recycling. The basics are stipulated in *the law of requisite variety* (Ashby, 1958), and the gist is that monocultures of industrially kept hi-yielding animals do require standard feeds, implying that only part of the feed biomass can be used. A mix of [feed]-resources can best be used with a mix of animal species, also needing consumers and processing industries that see divers products as an opportunity rather than a problem (Schiere *et al.*, 1999; Coppock *et al.*, 1987). Much work can and starts to be done, also within China on the use and preservation of local breeds, such as pigs, buffaloes, yaks and perhaps special goat and sheep breeds

- In terms of methodological issues a wide range of changes is worth mentioning, especially with concern to system approaches:
- Systems and learning systems Bawden (1991), Roling (1996), Ison *et al.* (1997), Checkland (1999), Ison & Russel (1999), Jackson (2000), Schiere *et al* (2004) and Langeveld & Röling (2006). This systems work refers especially to the need to look at wholes rather than details only (i.e. whole farms rather than only animals or crops), to the attention to change and system dynamics as in complex system theory, and to interdisciplinarity as much as use of farmers experiences (Chambers *et al.*, 1989; Ackoff, 1999; Rosenhead & Mingers, 2001 and Heemskerk *et al.*, 2003)[11]
- Farming systems research is an application of system thinking to issues of agricultural development (Conway & Barbier, 1990; Anandajayasekaram, 1997; Collinson, 2000; Jingzhong 2002; Conroy, 2005; Langeveld & Röling, 2006 and Patil, 2006).
- The use of modeling and scenarios such as in the cases of chapter 3 and 4 is a new approach to the work in farming system. Design of new systems is done across the world (NRC, 1989 and Vereijken, 1997), also using examples of the past (Thirsk, 1997)
- Typical work in this respect is done, for example, by Van Ittersum *et al.* (1998 & 2004); characterization of [dairy] farm systems with or without multiple goals (e.g. Morrison *et al.*, 1987; Conway 1987; De Wit *et al.*, 1988; Byerlee *et al.*, 1989; Traxler & Byerlee, 1993; Van De Ven, 1996; Jabbar *et al.*, 1997; Bosman *et al.*, 1997 and Vereijken, 1997;)
- Work with multi scale issues in sustainability and modeling for trade offs between regions, such as the lower run-off in one region that causes a water shortage elsewhere, or higher grain yields at the expense of livestock production, occurrence of both obesity and underfeeding (Pastore *et al.*, 2000; Giampietro, 2000; Giampietro & Pastore, 2001; Lopez-Ridaura, 2005 and Nordblom *et al.*, 2007a/b)
- Initial calculations of energy use in agriculture were done by Pimentel *et al* (1973), Sainz (2003), Pimentel (2004) and many others. It is followed up with calculations of nutrient balances (Aarts, 2000), and with work on so-called Life Cycle Analysis as done in an early stage by Pimentel et al. (1973), and later specifically for livestock by people such as Cederberg & Mattson (1999) or in China; LiShengli, pers. comm., 2006). The attention for dynamics in nutrient flows is described, for example, in Schlecht & Hiernaux (2004).

5 Future qualities, the practice and some cases

Many cases exist of change in the world, needing mind changes (soft system issues) and other cost price structures, but with beneficial effects on the environment (=process quality). The tendency is to formalize these good practices in codes of good conduct (Good Agricultural Practices) as now slowly formalized by for example FAO and IDF (FAO/IDF (2004). The following section lists cases at farm and regional, or even national level with 'mode-changes' to more sustainable dairy-farming. Other cases from other sectors are given in the main document (Ch 5 and box 5.1).

5.1. Mode changes in the 'dustbowl' of the central US-plains and in other countries

Severe wind erosion from 1931-39 devastated the central US plains, an event that was eventually named the 'Dust Bowl'. Native rangeland had been cultivated with tillage methods from the more humid US regions. In addition, booming wheat markets combined with unusually good rains and agricultural mechanization to accelerate cultivation, thus exposing large areas of potentially erodible soil. A drought from 1930-40 triggered

[10] See the Bourn Website
[11] Contact dr. Li Ou (liou@cau.edu.cn; lioucn@163bj.com); CORD/CIAD; CAU; Beijing.

wind erosion of excessively tilled land, produced the 'dust bowl'. A special committee recommended 'mode-changes' in a 1936 report to President Roosevelt. They noted that 'dust bowl' farm practices did not conform to the conditions of the Great Plains. The committee concluded that farming practices to reduce run-off and increase water storage in the soil were critical to agricultural success in a region of limited annual precipitation. A new Soil Erosion Service called for other farming practices and mindsets, with diversified crop and animal production. New management practices were developed and land policies revised to reward farmers for using contour plowing, listing, and strip cropping conservation practices. Wheat mono-culture evolved into wheat-fallow and wheat-sorghum-fallow cropping sequences that used precipitation stored as soil water during fallow to improve crop establishment. The practice of retaining crop residues on the soil surface during fallow increased precipitation storage about 20%, improving yields and permitting limited grazing. Ultimately this resulted in different relations between people, crops, livestock and the soil, as well as in different mindsets on agriculture (Lockeretz, 1978; Baumhardt, 2003). The same story repeated itself in a somewhat different manner in Southern Australia some 25 years ago and dust storms in China are common with lessons to be learned.

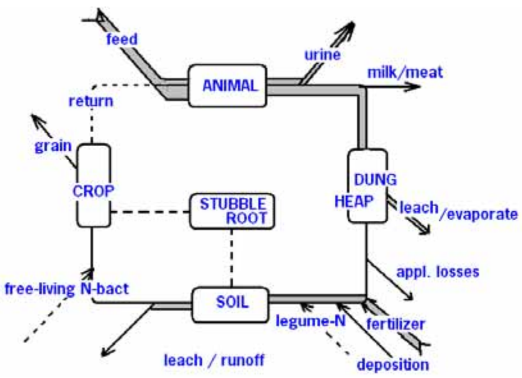
5.2. Mode changes for mixed farming to regenerate soils and communities

A typical case of mode changes for better process quality and sustainability in mixed farming is that of Machakos (Kenya). The key of this system lies in a variety of livestock feeding methods. Opportunities to integrate crops and livestock were neglected and the contribution of livestock to household -cash- income was limited. Farming was of the diversified kind and one change was to establish individual titles to land, visualized in demarcation and enclosure of grazing areas, a mode change in socio-cultural aspect. After this, some farmers recovered the grazing areas to provide grazing, timber and fuel. They use multipurpose animals, they do not aim at fast maturity, they even accept seasonal weight loses of their livestock, but they aim at high production on an area basis. Higher stocking rates can now be maintained using crop residues, i.e. higher population led to reduced grazing land areas, a change in the role of cattle, and replacement of livestock by crops as the main source of cash. Adjustment was key to sustainability and 'drivers' like shortages of land in parts of the district, combined with a national economic recession, local leadership, high costs of education and other expenses for raising children, led to voluntary family planning. The process was supported by a program in which people that had migrated to the city sent money back to the villages. In general, where land is scarce, fodder production is combined with soil conservation and stall feeding. Range improvement is done by using hedges, fences, bush and indigenous tree management and scratch plowing become attractive because they need labor but almost no cash (Tiffen et al., 1993 & 1994 and Slingerland, 2000).

5.3. Nutrient management in The Netherlands

The combination of cheap fertilizers, relatively cheap feed, technology focus and high demand for animal products combined into large scale pollution and nutrient loading in Western Europe during the 70ies and 80ies of the last century. The problems (continue to) occur in many places of the world, also in Asia (Steinfeld et al., 2006) However, the case of Dutch dairy is a good example of how change was effected, with trial, error and systematic work. The nutrient flow on the dairy farms was analyzed based on use of system diagrams (= chain diagrams on farm level) as shown in fig I.4. Remedies were suggested in the field of feeding, excreta management and re-cycling, fodder production, and mindsets of teaching, farmers and R&D. The result is a significant reduction of nitrogen-fertilizer, from over 500 to even less than 200 kg nitrogen / year in roughly one decade only (Aarts, 2000; Verloop *et al.*, 2006).

Figure I.4 A cyclical chain approach to be used for analysis of nutrient flows at farm level



5.4. Multiple goals of dairy in watershed management, changing mindsets in R&D

Erosion and water shortages have prompted work on better watershed management around the globe. Examples are described among others in case 5.2 and a typical case of a watershed development in India reported increased water levels in the subsoil, also positively affecting rural life. Livestock keeping, among others, was changed so as to affect real change, and livestock became a source of water rather than a sink. The essence was a changed mindset, in which livestock became a means rather than a goal in itself, from producing only milk and meat it became a producer of milk, meat as well as environmental services (Patil, 2006). Other examples of this kind of work are given in Grewal et al. (undated), Ho (2000 & 2001) and Liniger & Critchley (2007) , and of the introduction of for example agro-forestry and silvo-pastoral systems (Conroy & Paterson, 2000). This list is not exhaustive, it just shows the range of activities in this respect, often directly affecting the balance between poor and rich in the countryside. Associated work on changed mindsets and approaches in rural development takes place in China, e.g. by people from the CAU-CIAD[12], and impressive work in this respect is done in Australia, e.g. in groundbreaking initiatives on new forms of education at Hawkesbury (Bawden & Packham, 1998), and in the farmers-carried movement called Landcare (Campbell, 1996).

Table I.2. Water levels in a watershed management project in India where livestock management was geared to also produce environmental services

Characteristic	Before			After		
	Monsoon	Winter	summer	monsoon	Winter	summer
	Water level in wells (height of water column in meters)					
	6	4.5	0.6	10.5	8.4	1.5
	Crop yields (kg/ha)					
Cotton	560			880		
Groundnut	1000			1400		
Wheat		1000			2800	
Pulses	400	400		600	840	

5.5. From white veal to pink beef

(based on Gert Hemke; g.hemke@orange.nl and www.hemkenutriconsult.nl)

The production of 'white-calf meat' (=veal) in Holland strongly increased during the sixties and seventies of the last century. The calves are fed a by-product of the dairy. There is a good export market for this specialty meat product. The Netherlands currently produce 900.000 veal and 300.000 pink or young Holstein beef. The basics of the production process were that without ruminating the Holstein Friesian males reach high weight gains and the are ripe to be slaughtered at young ages while the milk with a low iron content result in a white colour meat. This veal product created much added value in export markets, mainly in France and Italy. However, in recent years the production of 'white-veal' started to encounter several problems. The main challenges were:

- lack of fibre (resulting in welfare problems),
- low iron levels in the milk feed created anemia (also resulting in health and welfare problems).
- the cost of milk products and -replacers strongly increased.

These problems were a reason to start the production of 'pink beef', implying change in minds of producers, R&D, processing business and consumers. It would have never taken off if it was not for the confidence of the manager product development of a 2 million ton feed / year coop company.

Critical success factors were to feed them with intensive diets, allowing effective ruminating, without having acidosis and off feed problems. This demands knowledge of rumen physiology and speed of rumination of all ingredients.

A special program started therefore in The Netherlands (early nineties) using Holstein Friesian (HF) bulls to produce 'pink beef'. They are fed a high density diet with 1 kg dry matter corn silage and *ad lib.* concentrates. The result is well tasting, tender meat with a pink colour, a much reduced cost price and diets with enough fibre and iron to ensure that no welfare problems occur. Rumen micro flora in the ruminating pink beef supply the animal with high quality proteins required for protein deposition. When the carcass is ripe at an early stage the meat will be more tender and at a younger age the muscle growth is more fibrous. To reach ripeness at younger ages the growth should be high, ensuring a good ration protein / fat growth. The HF cattle have high feed intake capacity, they grow fast and they stop growing at younger age due to ripeness (<350 kg at slaughter), in contrast with the heavy red beef animals which grow slower but which can grow till > 700 kg. This makes HF into sprinters among growing cattle, after the starting phase they can grow more than 1600 gram per day (more than one gram per minute). The advantages of high density diets are also that the dressing percentages increased, the carcass conformation improves and the level of intra muscular fat increases. Higher levels of intra muscular

[12] Contact dr. Li Ou (liou@cau.edu.cn; lioucn@163bj.com); CORD/CIAD; CAU; Beijing

fat contribute to better sensory quality of pink meat in comparison to veal. In this diet the level and digestion of iron is higher, resulting in a meat colour that is not white, not red, but pink. Currently more than 25 % of the veal in Holland is replaced by pink beef, and the future trends favour this type of product: good tasting, assured welfare, and using mainly plant by-products. The need for bio-fuel in the coming years, together with other developments as described in ch. 5 will continue to cause such mode changes in animal production, e.g. implying a need to produce meat out of fibre plant by products. The shift from white to pink veal is an example of such a change with potential also in China for the use of HF-calves.

5.6. Environmental services and a case of carbon sequestration in grassland ecosystems

Concerns about the environment give rise to all kind of developments, including payment for environmental services like carbon sequestration. 't Mannetje et al. (2007) discuss increasing scientific consensus on global warming, together with precautionary principles and fears of non-linear climate changes. They lead to actions to mitigate global warming, and carbon storage by forests is often considered to be a good way to reduce the CO_2 load in the atmosphere. Their book shows that tropical grasslands covering 50% of the earth's surface, are as important as forests for the sequestration of carbon. It gives results of a large five year on-farm research project in Latin America. Soil and vegetation carbon stocks of long-established pasture, fodder bank and silvi-pastoral systems on commercial farms were compared with those of adjacent forest and degraded land. The objective was to identify production systems that both increase livestock productivity and farm income and, at the same time, contribute to a reduction of carbon accumulation in the atmosphere. The project was carried out in four ecosystems: the Andean hillsides of the semi-evergreen forest in Colombia; the Colombian humid Amazonian tropical forest ecosystem; the sub-humid tropical forest ecosystem on the Pacific Coast of Costa Rica; and the humid tropical forest ecosystem on the Atlantic Coast of Costa Rica.

5.7. Initiatives on environmental management and livestock in South East Asia

International groups with a role in the design of better livestock farming systems include the World Bank and the FAO. For example, in April 2006 the World Bank approved US$7 Million For Livestock Waste Management in East Asia, involving China, Thailand, Vietnam and the FAO. The Project aims to reduce environmental and health damage from concentrated livestock production in the three participating countries. The project will integrate technological solutions, policy development and implementation, as well as capacity building and regional connections. Its global environment objective is to reduce livestock-induced, land-based pollution and environmental degradation of the South China Sea and the Gulf of Thailand. The Project will provide technical and financial support to demonstrate livestock waste management technologies; policy and strategy development; and project management and monitoring. The FAO will be responsible for implementation. The Global Environment Facility (GEF) aims to provide new and additional funding for measures to achieve agreed global environmental benefits in the six focal areas comprising climate change, biodiversity, international waters, ozone, land degradation, and persistent organic pollutants. GEF also supports the work of the global agreements to combat desertification and eliminate persistent organic pollutants.

5.8. Animal welfare

The world society for protection of animals (WSPA) aims to achieve better animal welfare in different areas of the world. In terms of numbers, intensive farming is the biggest cause of animal suffering today. Each year 61 billion farm animals are reared for meat, milk or eggs worldwide. The majority are kept in intensive systems where they are caged or confined, mutilated, and unable to express their natural behaviors. The WSPA helps animal welfare organizations to raise awareness and introduce proper legislation. One of the results is the launch of the model farm project, aiming to establish an international network of development and demonstration farms, to show that humane and sustainable farming is a practical and viable reality. The model farm project is a partnership between the World Society for the Protection of Animals (WSPA) and the Food Animal Initiative (FAI). The aim is to establish animal welfare as the fourth pillar of sustainable agriculture alongside social, economic and environmental concerns as part of WSPA's global World Farmwatch programme[13]. The basis lies in the growing global recognition for the need to develop sustainable agriculture. This has been driven by the growing number of examples of environmental degradation (pollution, reduced bio-diversity), social and economic failure (poverty, loss of rural livelihoods) and food safety issues (BSE, residues) that occurred as a result of agricultural activities. Another achievement is the Memorandum of Understanding on humane slaughter programs signed in China, with other animal welfare campaigns running in the Philippines, Indonesia, Taiwan, India, Korea, Argentina, Israel and European countries.

[13] see www.wspa.org.uk and www.faifarms.co.uk

References and suggested reading

Aarts, H.F.M., 2000. Resource management in a 'De Marke' dairy farming system. PhD thesis, Wageningen, 222pp

Ackoff, R.L., 1999. Disciplines, the two cultures and the scianities. System Research and Behavioural Science, 16, 533-537.

Altieri, M.A., 2002. Agro-ecology: the science of natural resource management for poor farmers in marginal environments. Agriculture, Ecosystems and Environment 1971: 1-24.

Anandajayaskeram, P., 1997. Farming system research: concepts, procedures and challenges. Journal for Farming Systems Research-Extension, vol. 7, No. 1.

Anon, 2004. The price of progress. China Economic Review, August 2004, p.

Appleby, M.C., 2005. Sustainable agriculture is human, humane agriculture is sustainable. Journal of agricultural and environmental ethics, 18, p. 293-303

Ashby, W.R., 1958. Requisite Variety and its Implications for the Control of Complex Systems. Cybernetica, 1, 83-99

Baumhardt, R. L. 2003. The Dust Bowl Era. In B.A. Stewart and T.A. Howell (eds.) Encyclopedia of Water Science, Marcel-Dekker, NY. pp. 187-191.

Bawden , R.J. and Packham R.G., 1998. Systemic Praxis in the Education of the Agricultural Systems Practitioner. Systems Research and Behavioral Science; 15, 403-412

Bawden, R., 1991. Systems Thinking and Practice in Agriculture. Journal of Dairy Science, 74: 2362-2373

Beghin, J.C., 2006. Evolving Dairy Markets in Asia: demand growth, supply adjustments and policy. Food Policy, 31, 3, 195-274

BODC, 2006. The research report on the development of the dairy industry in China. Beijing Orient Dairy Consultants Ltd., Beijing, PR of China (michael.cui@21dairy.com)

Björklund, J., Limburg, K.E. and Rydberg, T., 1999. Impact of production intensity on the ability of the agricultural landscape to generate ecosystem services: an example from Sweden. Ecological Economics, 29, p. 269-291.

Blackburn, H., 1998. Livestock Production, the environment and mixed farming systems. P. 114-123 in: Nell, A.J., 1998 (ed). Livestock and the environment. Proc. of the Intern. Conference on Livestock and the environment; held June 16-20, 1997 at Ede-Wageningen; organised by the World Bank and the FAO; International Agricultural Centre, Wageningen, The Netherlands 294 pp.

Bos, J., 2002. Comparing sspecialised and mixed farming systems in clay areas of the Netherlands under future policy scenarios: an optimisation approach. PhD thesis Wageningen, 2002

Bosman, H.G., Moll, H.A.J. and Udo, H.M.J., 1997. Measuring and interpreting the benefits of goat keeping in tropical farm systems. Agricultural Systems, 53, 349-372

Bot, G, Van de Braak, N., Challa, H., Hemming, S., Rieswijk, Th., Van Straten, G. and Verlodt, I., 2004. The solar greenhouse: state of the art in energy saving and sustainable energy supply. Paper at Greensys meeting 2004 (gerard.bot@wur.nl).

Britton, D.K., Hill, B., 1975, Size and efficiency in farming, Saxon House Lexington Books, Lexington, Mass., USA. 184pp

Brown, L.R. and Halweil, B., 1998. China's water shortage could shake world food security. World Watch magazine, July/August 1998, p 10-21

Byerlee, D., Muzaffar Iqbal and K.S. Fischer, 1989. Quantifying and valuing the joint production of grain and fodder from maize fields. evidence from northern Pakistan. Expl. Agric. (1989), volume 25, pp. 435-445.

Cáceres Villanueva, L., Delatorre, J., De la Riva, F. and Monardes, V., 2003. Greening of arid cities by residual water reuse: a multidisciplinary project in northern Chile. Ambio, 32, 4, 264-268.

Campbell, C.A., 1996, Land literacy in Australia: landcare and other new approaches to inquiry and learning for sustainability. In Budelman, A. (ed). Agriculture R&D st the crossroads: merging systems research and social actor approaches. Royal Tropical Institute, Amsterdam p 169-184.

Case, K. & Fair, R., 2002 Principles of Economics, Prentice Hall Business Publishing

Cederberg, C. and Mattsson, B., 1999. Life cycle assessment of milk production – a comparison of conventional and organic farming. P1 – 33, in Mattsson, B., 1999. Environmental Life Cycle Assessment (LAC) of Agriculural Food Production. Doctoral thesis, Swedish University of Agricultural Sciences, Alnarp, 1999.

Chambers, R., A. Pacey, and Thrupp, L.A., 1989. Farmers first: farmer innovation and agricultural research. London: Intermediate Technology Publications. 218 pp.

Checkland, P.B., 1999. Systems thinking, systems practice, including a 30-year retrospective. John Wiley and Sons, Chichester.330 pp.

Collinson, M., 2000. A History of Farming Systems Research. CABI Publishing, Oxon, UK. pp. 432

Conway, G.R., 1987.The properties of agro-ecosystems. Agricultural Systems 24, 95-117

Conway, G.R. and E.B. Barbier, 1990. After the green revolution, Sustainable agriculture for development, Earthscan Publications Ltd. London, 205 p.

Conroy, C., 2005. Participatory Livestock Research, a guide. Bourton-on-Dunsmore, UK; ITDG Publishing, Bourton-on-Dunsmore (UK; ISBN 1 85339 577 3; 304 pp

Conroy, C., and Paterson, R.T., 2000. A review of the literature on silvipasture management and development on common lands in semi-arid regions. NRI, Chtahma, UK and BAIF, Pune, India

DAC, 2006. China Dairy Yearbook. Dairy Association of China. China Agriculture Press, 552 pp.
De Haan, C. Steinfeld, H. & Blackburn, H., 1997. Livestock & the environment: finding a balance. WREN media: Fressingfield, Eye, Suffolk, UK. Organisation of the United Nations, the United States Agency for International Developments and the World Bank.
De Wit, C.T., H. van Keulen, N.G. Seligman and I. Spharim, 1988. Application of interactive multiple goal programming techniques for analysis of regional agricultural development. Agric. Syst. 26: 211-230.
De Zwart, H.F., 1996. Analyzing energy options in greenhouse cultivation using a simulation model. PhD thesis Wageningen University.
De Zwart, H.F. and Kempkes, F.L.K., 2007. Characterisation of cooling devices for greenhouses. Contribution to Greensys 2007 (feije.dezwart@wur.nl).
Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S and Courbois., 1999. Livestock to 2020; the next food revolution. Food, agriculture and the environment paper 28. IFPRI-Washington, FAO-Rome, ILRI-Nairobi, 72 pp.
Devendra, C., Sevilla, C. eds. 1995. Crop-animal interaction. IRRI discussion paper series no. 6. International Rice Research Institute. P.O.Box 933, Manilla, Phillipjnes. 572 pp.
Devendra, C., 1997. Improvement of livestock production in crop- animal systems in rainfed agroecological zones of SE Asia. An assessment in 9 countries; ILRI, Nairobi, Kenya, 102 pp
Ding, S., Pandey, S., Chen, C. and Bhandari, H., 2004. Drought and farmers' coping strategies in poverty-afflicted rural China. Instiute for Development Policy and management (IDPM), Manchester
Donceva, M., Voorbergen, M., Zwanenberg, A., 2004. Growth Opportunities in global dairy. RaboBank International, www.rabobank.com/far
Dong S. K., 2003. Grassland degradation and ecological restoration in cropping-pastoral zone of northern china. Report of post-doctoral research, Beijing Normal university (unpublished)
Dong, S.K., Long, R.J. and Kang M.Y., 2003. Milking and milk processing: traditional technologies in the Yak farming system of the Qinghai-Tibetan Plateau, China. International Journal of Dairy technology, 56 (2), p 86 – 93
Dong, J., Hengsdijk, H., Dai, T., De Boer, W., Qi, J., Cao, W., 2006.Long-term effects of manure and inorganic fertilizers on yield and soil fertility for a winter wheat-maize system in Jiangsu, China. Pedosphere 16: 25-32.
Fang, Y., Yang J.S., Kjaer, S.S., Gerber, P., Ke, B.S. and Menzi, H., undated. Area-wide integration of specialised livestock and crop production in Jiangsu province, China. Mimeograph.
FAO, 2007. The state of the world's animal genetic resources for food and agriculture. Commission on genetic resources for food and agriculture. FAO, Rome, 511 pp.
FAS, 2001. Global Agriculture Information Network: P.R. of China, Dairy and Products, Annual Report 2001. Foreign Agricultural Service; United States Department of Agriculture.
FAO, 2004. Guide to good dairy farming practices, A joint publication of the International Dairy Federation and the Food and Agricultural Organization of the United Nations, Rome, 28 pp
Gardner, G. 1997. Recycling organic waste: from urban pollutant to farm resource. Worldwatch Paper 135. Worldwatch Institute, Washington. 59 pp
Gerber, P., Chilonda, P., Fraceschini, G. and Menzi, H., 2005. Geographical determinants and environmental implications of livestock production intensification in Asia. Bioresource Technology, 96, 263-276
Giampietro, M., 2000. Complexity and scales: the challenge for integrated assessment. Keynote paper for the European Forum on Integrated Environmental Assessment workshop on 'Scaling Issues in Integrated Assessment' held in Machelen, the Netherlands, July 12-19 2000. To be published in an edited book (J. Rothman and M. van Asselt) on: Scaling issues in integrated assessment – Concerted Action European Forum on Integrated Environmental Assessment funded by the Environment and Climate Programme of the EC-DG XII.
Giampietro, M., Pastore, G., 2001. Operationalizing the concept of sustainability in agriculture: characterizing agroecosystems on a multi-criteria, multiple-scale performance space. In: S.R. Gliessman (ed). Agroecosystem Sustainability: developing practical strategies. CRC Press, Boca Raton, pp.177-202.
Giovannucci, D., Silveri., P., Joensen, L., 2005 (eds). Organic agriculture and poverty reducton in Asia, China and India focus. International Fund for Agricultural Development (unpublished).
Gorissen, P.J.A. and E.B. Vermeer. Development of milk production in China in the 1980s. PUDOC, Wageningen. 1985.
Grandin, T., 2005. Maintenance of good animal welfare in beef slaughter plants by use of auditing programs. Veterinary Medicine Today, p. 370-373
Grandin, T., 2003. Tranferring results of behavioral research to industry to improve animal welfare on the farm, ranch and the slaughter plant. Applied Animal Behaviour Science, 81, 215-228.
Grewal, S.S., Samra, J.S., Mittal, S.P., and Agnihotri, Y., undated. Sukhomajri concept of integrated watershed management. Bulletin no. T-26/C-5; Central Soil and Water Conservation Research and Training Institute, Research Centre; Chandigarh – 160 019 India, 157 pp.
Halweil, B., 2002. Home grown, the case for local food in a global market. WorldWatch paper 163. Washington
Harris, C., 2004. The cycle of meat and food processing. Meat Processing Global, July/August, p 6-7
Heemskerk, M., Wilson, K. and Pavao-Zuckerman, M., 2003. Conceptual models as tools for communication across disciplines. Conservation Ecology, 7, 3
Ho, Y.W. and Chan, Y.K. (eds.), 1998. Proceedings of the regional workshop on area-wide integration of crop-livestock activities. June 18 – 20, 1998, Bangkok, RAP-publication 1998/19. FAO Regional Office for Asia and the Pacific. Bangkok, Thailand. 86 pp.

Ho, P. 1999. Rangeland Policy, Pastoralism and Poverty in China's Northwest; Ningxia Province in the Twentieth Century. University of Leiden.
Ho, P, 2000. China's Rangelands under Stress: A comparative study of pasture commons in the Ningxia Hui Autonomous Region. Development and Change, Vol. 31, No. 2, March 2000, pp. 385-412
Ho, P., 2001 Rangeland Degradation in North China Revisited? A Preliminary Statistical Analysis to Validate Non-Equilibrium Range Ecology", Journal of Development Studies, Vol. 37, No. 3, 2001, pp. 99-132
Hu, Dinghuan, 2004. Survey report of dairy industry in China. Mimeograph (dinghuanhu@vip.sohu.com)
Hu, Dinghuan, Fuller, F., Readron, T., undated; Impact of rapid development of supermarket on dairy in China. Paper presented at FAO-workshop on Structural Change in the Livestock Sector – Social and environmental implications for policy making; Bankor, Thailand (dinghuanhu@vip.sohu.com)
Huibers, F.P. & Van Lier, J.B., 2005. Use of wastewater in agriculture: the water chain approach. Irrigation and Drainage, 54, 53-59
IDF, 2007. The world dairy situation 2007. Bulletin of the International Dairy Federation. 423/2007. Brussels
Ison, R.L., Russell, D.B., 1999. Agricultural extension and rural development: breaking out of traditions. A second-order systems perspective. Cambridge university press. 231 pp.
Ison, R.L., Maiteny P.T. and Carr, S., 1997. System methodologies for sustainable natural resources, research and development. Agricultural Systems, 55(2), p257-272.
Jabbar, M.A., Tambi, E.T. and Mullins, G., 1997. A methodology for characterizing dairy marketing systems. Working document 3. Market-oriented smallholder dairying research; International Livestock Research Institute (ILRI); March 1997; 62 pp
Jackson, M.C. 2000. Systems Approaches to Management. Kluwer Academic / Plenum Publishers. New York / Boston / Dordrecht / London / Moscow. 448 pp.
Jingzhong, Y. 2002. Processes of Enlightenment: farmer initiatives in rural development in China. PhD-thesis, Wageningen University, the Netherlands, pp 286.
Kok, K., Rothman, D.S. and Patel, M., 2006. Multi-scale narratives from an IA perspective: part I. European and Mediterranean scenario development. Futures, b38, 261-284
Langeveld, H. and Röling, N. (eds), 2006. Changing European farming Systems for a better future; new visions for rural areas. Wageningen Academic Publishers. 479 pp.
Lantinga, E.A. and Van Laar, H.H.H. (eds), 1997. The renaissance of mixed farming (in Dutch). AP Minderhoudhoeve Series No. 1, Wageningen Agricultural University, The Netherlands
Larovere, R., 1998. Extensive pig production in Extremadura, Spain: the case of the "Dehesa". Paper presented at the Workshop for the International Course: Livestock & Environment Interactions, March 28th-April 5th, International Agricultural Centre (IAC), Wageningen, The Netherlands
Li Yanping, 2007. Childhood obesity in China: prevalence, determinants and health. PhD thesis Wageningen, The Netherlands, 182 pp.
Lockeretz, W.,1978. The lessons of the dustbowl. American Scientist, 560-569
Liniger, H.P., and Critchley, W., 2007 (eds). Where the land is greener – case studies and analysis of soil and water conservation initiatives worldwide; CTA / FAO / UNEP / CDE; WOCAT-Wageningen.
Lopez-Ridaura, S., 2005. Multi-Scale Sustainability Evaluation. A framework for the derivation and quantification of indicators for natural resource management systems. PhD-thesis, Wageningen; Tropical Resource Management Papers 68, Wageningen, The Netherlands.
Lu, Hualiang, 2007. The role of Guanxi in buyer-seller relationships in China, a survey of vegetable supply chains in Jiangsu province. Wageningen Academic publishers. 240 pp.
Ma, Hengyun, Rae, A.N, Jikun, H. and Rozelle, S., 2007. Enhancing productivity on suburban dairyfarms in China. Agricultural Economics, 37, p. 29-42
MacRae, J., O'Reilly and Morgan, P., 2004. Desirable characteristics of animal products from a human health perspective. Livestock Production Science.
Martinot, E. and Li Junfeng, 2007. Powering China's Development, the role of renewable energy. WorldWatch report 175. WorldWatch Institute, Washington, US.
Medema, D., 2006. First greenhouse to deliver heating to domestic housing, rose-grower is the first one (in Dutch). Vakblad voor Bloemisterij, 46, p. 48 -49
Millstone, E. and Lang, T., 2003. The atlas of food, who eats what, where and why. Earthscan, London, 128 pp.
Molden, D., 2007. Water for food, water for life, a comprehensive assessment of water management in agriculture. Earthscan . IWMI, London
Monroy, O., Fama, G., Meraz, M., Montoya, L. and Macarie, H., 2000. Anaerobic digestion of waste water treatment in Mexico, state of technology. Wat. Res., 34, 6, p. 1803-1816
Morrison, D.A., Kingwell, R.S., Pannell, D.J. and Ewing, M.A., 1987. A mathematical programming model of a crop-livestock farm system. Agric. Syst., 20: 243-268
Mureithi, J.G., R.S. Tayler and W. Thorpe, 1995. Productivity of alley farming with Leucaena (Leucaena leucocaephala Lam. de Wit) and Napier grass (Pennisetum purpureum K. Schum) in coastal lowland Kenya. Agroforestry Systems 31: 28: 1-20.

Nell, A.J., 1998 (ed). Livestock and the environment. Proceedings of the International Conference on Livestock and the environment; held June 16-20, 1997 at Ede-Wageningen; organised by the World Bank and the FAO; published by the International Agricultural Centre, Wageningen, The Netherlands 294 pp

Nordblom, T., Hume, I., Crewell, H., Glover, M., Hean, R., Finlayson J., and Wang, E.; 2007a. Minimizing cost of environmental service provision: water yield, salt-load and biodiversity targets with new tree planting in Simmons Creek Catchment, NSW, a dry-land farming / grazing area. Australian Agricultural and Resource Economics Society Annual Conference; 13-16 Feb 2007, Queenstown, New Zealand

Nordblom, T., Hume, I., Finlayson J., Kelly, J., Welsh, R. And Hean R., 2007b. Downstream benefits vs. upstream costs of land use change for water-yield and salt-load targets in the Macquarie Catchment, NSW. Australian Agricultural and Resource Economics Society Annual Conference; 13-16 feb 2007, Queenstown, New Zealand

Nou, J., 1967. Studies in the Development of Agricultural Economics in Europe. Almquist & Wiksells Boktryckeri AB, Uppsala. 611 pp.

NRC, 1989. Alternative agriculture. National Research Council. National Academy Press, 449pp

Oomen, G.J.M., E.A. Lantinga, E.A. Goewie, and K.W. Van Der Hoek, 1998. Mixed farming systems as a way towards a more efficient use of nitrogen in European Union agriculture. Environmental Pollution 102, S1 (1998) 697-704.

Owango, M., Lukuyu, B., Staal, S.J., Kenyanjui, M., Njubi, D. and Thorpe, W., 1998. Dairy co-operatives and policy reform in Kenya: effects of livestock service and milk market liberalisation. Food Policy, Vol. 23, No 2., pp. 173-185

Owen, E. and Jayasuriya, M.C.N., 1989. Use of crop residues as animal feeds in developing countries – a review. *Research in Development in Agriculture* 6: 129-138.

Owen, E., Kitalyi, A., Jayasuriya, N. and Smith, T., 2005 (eds). Livestock and Wealth Creation; improving the husbandry of animals kept by resource-poor people in developing countries. Nottingham University Press, Nottingham, UK., 601 pp.

Parthasarathy Rao P., Birthal, P.S., Ndjeunga, J., 2005. Crop-livestock economies in the semi-arid tropics: facts, trends and outlook. Patancheru 502324. Andhra Pradesh, India. International Crops research Institute for Semi-arid Tropics, 68 pp. ISBN 92-9066-476-2

Pastore, G., Giampietro, M., Mayumi, K., 2000. Societal metabolism and multiple-scale integrated assessment-empirical validation of the theoretical framework. Population & Environment, V .22 (2)

Patil., B.R., 2006. Dynamics of livestock development in Gujarat (India); experiences of an Indian NGO., PhD thesis, Wageningen University; Wageningen, 158 pp.

Patil. B.R., Rangnekar D.V. and Schiere J.B. 1993. Modelling of crop livestock integration: effect of choice of animals on cropping pattern. In: Feeding of ruminants on fibrous crop residues. Proceedings of an international workshop held at the National Dairy Research Institute, Karnal (Haryana-India), February 4-8, 1991. Indian Council of Agricultural Research, New Delhi, 1993, p336-343.

Peterson, H.C., Wysocki, A. and Harsh, S.B., 2001. Strategic choice along the vertical coordination continuum. International Food and Agribusiness Management Review, 4, 149-166

Peverelli, P., 2005. Chinese Corporate Identity; Routledge, ISBN 0415372089

Pica-Ciamarra U. (2002), *Agrarian reforms in an neoinstitutional perspective: the Philippine experience* – PhD Dissertation, University of Rome, Rome, Italy.

Pimentel, D., 2004. Livestock production and energy use. Encyclopedia of Energy, Volume 3, Elsevier

Pimentel, D. and M. Pimentel (1996). Food, energy and society. Revised edition. Published by the University press of Colorado.

Pimentel, D., Hurd, L.E., Belotti, A. C., Forster, M.J., Oka, I.N., Sholes, O.D. and Whitman, R.J., 1973. Food Production and the Energy Crisis, Science 2. Vol. 182 (4111), 443-449

Pimentel, D., Houser, J., Preiss, E., White, O., Fang, H., Mesnick, L., Barsky, T., Tariche, S., Schreck, J. and Alpert, J., 1997. Water resources: agriculture, the environment and society. BioScience 47(2), 97-106. (Quoted in D. Pimentel (2004) Livestock production and energy use. Encyclopedia of Energy, Volume 3, Elsevier).

Postel, S., 2005. Liquid Assets, the critical need to safeguard freshwater ecosystems. State of the world library, WorldWatch. Washington

Postel, S. and Richter, B., 2003. Rovers for life: managing water for people and nature. Island Press.

Pretty, J. N., Ball, A. S., Lang, T. and Morison, J. I. L., 2005. Farm costs and food miles: An assessment of the full cost of the UK weekly food basket. Food Policy, 30(1): 1-19.

RABO, 2006. China's dairy sector, catching up with demand growth? Written by Lillian Lou. RaboBank International. F&A Research and Advisory. October 2006.35 pp.

Röling, N., 1996. Towards an interactive agricultural science; or are we Norsemen in Greenland? European Journal of Agricultural Education Extension. 2(4) p35-48

Rosenhead, J. and Mingers, J., 2001 (eds). Rational Analysis for a Problematic World revisited; problem structuring methods for complexity, uncertainty and conflict. 2nd Edition. John Wiley and Sons, Ltd. Chichester, New York, Weinheim, Brisbane, Singapore, Toronto. 366 pp.

Rosa, C., 2006. Greenhouses as source of energy, turning point and catalyst (in Dutch). Innovatie netwerk / Stichting Innovatie Glastuinbouw; Utrecht / Bleiswijk.

Rostov, W.W., 1960. The stages of economic growth, a non-communist manifesto. Cambridge University Press, London / New York; 179 pp

Ruben, R., Van Boekel, M., Van Tilburg, A. and Trienekens, 2007, Tropical Food Chains, governance regimes for quality management. Wageningen Academic publishers. 310pp.

Sainz, R.D., (2003). Fossil fuel component. Framework for calculating fossil fuel use in livestock systems. www.fao.org/wairdocs/lead/x6100e/x6100e00.htm#Contents and www.lead.virtualcentre.org/en/dec/fossil/default.htm

Schiere, J.B., Nell, A.J. and Ibrahim, M.N.M., 1988. Feeding of urea-ammonia treated rice straw, World Animal. Review. 65, p 31 - 42.

Schiere, J.B., De Wit, J., Steenstra, F.A. and Van Keulen, H., 1999. Design of farming systems for low input conditions: principles and implications based on scenario studies with feed allocation in livestock production. Netherlands Journal of Agricultural Science, 47 (2) 169 – 183

Schiere, J.B. and Van Keulen, H., 1999. Rethinking high input systems of livestock production: a case study of nitrogen emissions in Dutch dairy farming. Tropical Grasslands, 33, 1-10

Schiere, J.B., Lyklema, J., Schakel, J. and Rickert K., 1999. Evolution of farming systems and system philosophy. Systems Research and Behavioral Sciences, 16, 4

Schiere, J.B. and Van Der Hoek, R., 2001. Livestock keeping in urban areas, a review of traditional technologies. Animal Production and Health Papers 151, FAO, Rome.

Schiere, J.B. and Kater, L., 2001. Mixed crop-livestock farming. A review of traditional technologies. Animal Production and Health Papers 152, FAO, Rome.

Schiere, J.B., Groenland, R., Vlug, A. and Van Keulen, H., (2004). System Thinking in Agriculture: an overview. Chapter 4 and p 57-86 in Emerging Challenges for farming systems - lessons from Australian and Dutch agriculture; edited by Ken Rickert. Publication Number 03/053, Rural Industries Research and Development Corporation. P.O.Box 4776, Kingston Act 2604. 243 pp.

Schiere J.B., Baumhardt R.L., Van Keulen H., Whitbread A.M., Bruinsma A.S., Goodchild A.V., Gregorini P., Slingerland M.A. and Hartwell B. (2006). Mixed crop-livestock systems in semi-arid regions. P 227-291 and Ch. 8 in Dryland Agriculture, G.A. Peterson, Unger, P.W. and Payne, W.A. (ed.), 2nd edition.; Agron. Monogr. 23. American Society of Agronomy; Crop Science Societyy of America, Soil Science Society of America;, Madison, Wisc., USA ISBN 0-89118-160-1

Schlecht, E. and Hiernaux, P., 2004. Beyond adding inputs and outputs: process assessment and upscaling in modeling nutrient flows. P. 303-319 in Nutrient Cycling in Agroecosystems, 70; Kluwer Academic Publishers

Scialabba, N.E. and Hattam, C., 2002. Organic agriculture, environment and food security. Food and Agriculture Organization of the United Nations. Rome, 252 pp.

Shi, H. and Zhang, L. 2006. China's rapid industrialization and the challenges for environmental governance. Environmental Politics, 15, 2, p. 272-293.

Sijtsma, H., 2004. Blueprint Sino-Dutch Dairy Training & Demonstration Center. Zhengzhou, Henan Province, P.R. China (henk.sijtsma@yahoo.com).

Simpson, J.R., Xu Cheng and Miyazaki, A., 1994; China's Livestock and Related Agriculture, projections to 2025; CAB International, Wallingford, UK., 474 pp.

Slingenbergh, J., Gilbert, M., De Balogh, K. and Wint, W., 2004. Ecological sources of zoonotic diseases. Rev. sci. tech. Off. Int. Epiz., 23 (2), 467-484

Slingerland, M.A., 2000. Mixed farming: Scope and Constraints in West African Savanna, PhD-htesis Wageningen.

Slingerland., M.A., 2001. Crop and Livestock: living apart together. P 115-128 in Tielkes, E., Schlecht, E. and Hiernaux, P., 2001 (eds). Elevage et gestion de parcours au Sahel, implications pour le développement. Verlag Ulrich E. Grauer, Beuren, Stuttgart / Germany

Staniforth, A.R., 1982. Straw for fuel, feed and fertilizer. Farming Press, Ipswich, Suffolk, 153 pp.

Steinfeld, H., De Haan, C., and Blackburn, H., 1996. Livestock-Environment Interactions, issues and Options. (WREN media, Fressingfield, Eye, Suffolk, UK). European Commission Directorate-General for Development.

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and De Haan, C., 2006. Livestock's long shadow, environmental issues and options. Food and Agriculture Organization of the United Nations. Rome

Sumberg, J., 1998. Mixed Farming in Africa, the search for order, the search for sustainability. Land Use Policy, vol. 15, no. 4. Pp. 293-317

Sundstol, F. and Owen, E., 1984. Straw and other fibrous by-products as feed. Elsevier Science Publishers. Amsterdam. Developments in Animal and Veterinary Sciences 14. ISBN 0-444-42302-8, 608 pp

Tamminga, S., 1996. A review on environmental impacts of nutritional strategies in ruminants. J. Anim. Sci., 74: b3112-3124.

Thirsk, J., 1997. Alternative Agriculture, a History; from the black death to the present day. Oxford University Press. Oxford / New York, 365 pp.

Thornton, P.K., Krushka, R.L., Henniger, N., Kristjanson, P.M., Reid, R.S., Atieno, F., Odero, A.N., Ndegwa, T., 2002. Mapping Poverty and Livestock in the Developing World. ILRI, Kenya

Tiffen, M., Mortimer, M., and A.C. Ackello-Ogutu, 1993. From agropastoralism to mixed farming: the evolution of farming systems in Mackakos, Kenya, 1930-1990. Agricultuiral Administration Network. Network paper 45. Overseas Development Institute, London, 35 p.

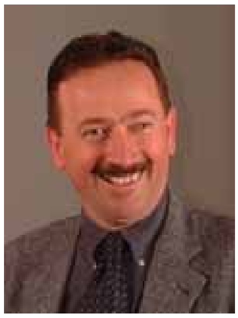
Tiffen, M., Mortimer, M., and F. Gichuki, 1994. Population Growth and Environmental Recovery: policy lessons from Kenya. Gatekeeper series 45, International Institute for Enviornment and Development, London, 26 pp.

't Mannetje, L., Amézquita, M.C., Buurman, P. and Ibrahim, M.A., 2007 (eds). Carbon sequestration in tropical grassland ecosystems. Wageningen Academic Publishers, Wageningen 224 pp
Traxler, G. and D. Byerlee, 1993. A joint-Product Analysis of the adoption of modern cereal varieties in developing countries. Amer. J. Agr. Econ., 75 (November 1993): 981-989.
Van De Ven, G.W.J.,1996. A mathematical approach to comparing environmental and economic goals in dairy farming on sandy soils in The Netherlands. PhD thesis. Wageningen Agricultural University, Netherlands.
Van der Ploeg, J.D. and Long, A., 1994 (Eds) Born from within: practice and perspectives of endogenous rural development. Van Gorcum, Assen, The Netherlands, 298 pp.
Van Ittersum, M.K., R. Rabbinge and H.C. Van Latesteijn, 1998. Exploratory land use studies and their role in strategic policy making. Agric. Syst. 58: 309-330
Van Ittersum, M.K., Roetter, R.P., Van Keulen, H., De Ridder, N., Hoanh, C.T., Laborte, A.G., Aggarwal, P.K., Ismail, A.B. and Tawang, A., 2004. A systems network (SysNet) approach for interactively evaluating strategic land use options at sub-national scale in South and South-east Asia. Land Use Policy, 21, p 101-113
Van Keulen, H. and Schiere, H., 2004. Crop-Livestock systems: old wine in new bottles? In Fischer, R.A., Turner, N., Angus, J., McIntire, L., Robertson, M., Borrel, A., Lloyd, D. (Eds.). New directions for a diverse planet. Proceedings for the 4th International Crop Science Congress, Brisbane, Australia, 26 Sep - 1 Oct 2004. The procs are available at www.cropscience.org.au
Van Veenhuizen, R., (2006). Cities farming for the future. Urban agriculture for green and productive cities. RUAF (Resource Centre on Urban Agriculture and Forestry), Leusden, the Netherlands, pp. 349-379.
Van Zyl, J., Binswanger, H. and Thirtle, C., 1995. The relationship between farm size and efficiency in South African agriculture. Policy research working paper 1548. The World Bank, Agriculture and Natural resources Department, 45 pages
Verburg, P.H. and Van Keulen, H., 1999. Exploring changes in the spatial distribution of livestock in China. Agricultural Systems, 62, p 51-67
Vereijken, P., 1997 A methodical way of prototyping integrated and ecological arable farming systems (I/EAFS) in interaction with pilot farms. European Journal of Agronomy. 7, 235-250.
Verloop, J., Boumans, L.J.M., Van Keulen, H., Oenema, J., Hilhorst, G.J., Aarts, A.F.M. and Sebek, L.B.J., 2006. Reducing nitrate leaching to groundwater in an intensive dairy farming system. Nutrient Cycling in Agroecosystems, 74, 59-74
Wackernagel, M., Schulz, N.B., Deumling, D., Callejas Linares, A., Jenkins, M., Kapos, V., Monfreda, C., Loh, J., Myers, N., Norgaard, R. and Randers, J., 2002. Tracking the ecological overshoot of the human economy. PNAS, 99 (14), pp. 9266-9271
Wattiaux, M.A., Frank, G.G., Powell, J.M., Zhiguo Wu and Yuyuan Guo, 2002. Agriculture and dairy production systems in China: an overview and case studies. Babcock Institute Discussion Paper, No. 2002-3; The Babcock Institute, College of Agricultural and Life Sciences, 240 Agriculture Hall, 1450 Linden Drive, Madison Wisconsin 53706; http://babcock.cals.wisc.edu
Webster, D. and Ti Le-Huu (eds), 2004. Guidelines on Strategic Planning and Management of Water Resources. Economic and Social Commission for Asia and the Pacific. United Nations, 94 pp., ISBN: 92-1-120411-9
Wolf, J., Van Wijk., M.S., Cheng, X., Hu, Y, Van Diepen, C.A., Jongbloed, A.W., Van Keulen, H., Lu, C.H. and Roetter, R. 2003. Urban and peri-urban agricultural production in Beijing municipality and its impact on water quality. Environment and Urbanization, 15, 2, p141-156
Wolfe, E.C., in press. Interactions between crop and livestock activities in rainfed farming systems (TWolfe@csu.edu.au)
Wolman, M.G. and Fournier, F.G.A., 1987 (eds). Land transformation in Agriculture. Scope 32. John Wiley & sons, Chichester / New York / Brisbane / Toronto / Singapore. 531 pp.),
Wu, Dingrong, Qiang Yu, Changhe Lu, Huib Hengsdijk, 2006. Quantifying production potential of winter wheat in the North China Plain. European Journal of Agronomy 24: 226-235
Wu, D.R., Yu, Q., Wang, Enli, Hengsdijk, H., 2008. Impact of spatial-temporal variations of climatic variables on summer maize yield in North China Plain, international Journal of Plant Production. (accepted, in press)
Zhang, X., 2001. Shanghai Consumer Studies, with attention to livestock, dairy and horticulture. Report 7.01.03; Agricultural Economics Institute, The Hague
Zhang, X., 2005. Chinese Consumers' Concerns about food safety; the case of Tianjin. Journal of International Food & Agribusiness Marketing, 17, 1, p. 57-69
Zhang, X. Y., Dagevos, H., He Y.N., van der Lans, I., and Zhai, F. (in press). Consumption and Corpulence in China: A Segmentation Study of Consumers from the Perspective of Food Products. Food Policy (in press).
Zhang, X.Y, Yang J.X and Fu, X.H., 2006. Vegetable Supply Chains of Supermarkets in Sichuan, China and the Implications for Supply Chain Management. Acta Horticulturae Number 699
Zhang, X.Y., Fu, X., Yang, J., and S. van Wijk, 2007. The Evolution of the Chinese Vegetable Supply chains'. In Symposium Supply Chain Management , International Society for Horticultural Science, Sept 2007 Hanoi, Vietnam.

The authors and participating Institutions

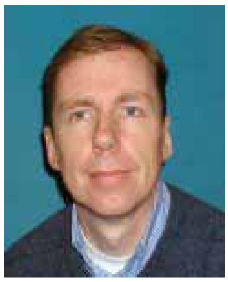
Farming has to continuously find new ways due to, for example new technology, globalisation, price changes and climate change. This implies a need for the design of new systems and relations on interfaces of agriculture and society. Hans Schiere worked for this report with Wageningen International (www.wi.wur.nl) to identify such new systems and approaches. He uses creative and interactive workshops, desk-studies and consultancies to think out-of-the-box while looking at systems in their total context. The approach is based on extensive experience in agricultural development in Europe, the Americas, Africa and especially Asia.

The Animal Sciences Group (ASG) is involved in research for food, feed and farm, concerning livestock production. It does scientific and applied research as part of Wageningen University and Research Centre (www.asg.wur.nl). The ASG serves the business community, government and students with new insights and products for the production of healthy food and ‘quality of life’. Kees de Koning manages the farm management and food chain section and he has a strong background in the quality of milk. He also serves international bodies such as the International Dairy Federation



The Agricultural Economics Institute (LEI-WUR) develops economic expertise for government bodies and industry in food, agriculture and the natural environment www.lei.wur.nl . Dr.Xiaoyong Zhang is a highly qualified agricultural economist serving as expert in food chains and consumer behavior. Being a native Chinese from Beijing, she has been involved in major studies regarding the food chains in China, such as the vegetable chain.

Plant Research International (PRI) is one of the research centers of Wageningen University and specializes in strategic and applied research. Within the Business Unit Agrosystems research focuses on the design and development of socially desirable production systems, which are ecologically and economically responsible. Huib Hengsdijk is a leading systems modeler and agronomist who (co) authored about 30 peer-reviewed articles. His specific interest is in land use analysis and design with due attention for the interplay between crop and livestock systems.



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