Strategic development of vegetable supply chains in Dezhou

Result of the fact finding mission from February 27 to March 2, 2017

Authors: Chris de Visser, Joost Snels, Eric Poot & Qiu Yu Tong

WAGENINGEN
UNIVERSITY & RESEARCH

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Photo cover: Traditional Chinese solar greenhouse in Dezhou, © Chris de Visser

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Preface

The collaboration between China and The Netherlands is getting more and more intense. Especially on the food sectors where China strives for modernization, The Netherlands has much to offer based on its present day level of food supply and export. Wageningen University & Research (WUR) has worked together for decades with the Dutch government, private companies, farmers, professional education and advisory services to modernize Dutch agriculture to the standard we witness today. Thus, it contributed to the development of a sector that now has a share of 10% in the Dutch economy and generates 50 billion euro on added value while realizing an export volume of 80 billion euro. This last figure represents 25% of total Dutch exports. This indicates not only the importance of the sector to the Netherlands but also illustrates the competitiveness of the agrofood complex. This is supported by a high level of technology being used in a modern production, logistics and processing value chain. The Dezhou municipality has expressed a desire to modernize the Chinese horticulture sector and is working hard and effectively to do so. To support this process, WUR is prepared to bring in its expertise and knowledge. A Centre of Excellence (CoE) to propel the development of Dezhou's horticulture production and value chains, would be very helpful to effectively implement WUR's expertise in Dezhou horticulture. This report provides a rough design of how this CoE could be organised and it also gives many suggestions on technologies that could be incorporated in this centre. We expect that a Dezhou Centre of Excellence on horticulture production and logistics will play a pivot role in the upgrading of the Dezhou horticultural sector and are looking forward to a close and fruitful co-operation in Dezhou area of Shandong province in China.

Ernst van den Ende, General Manager of Wageningen Plant Research
Raoul Bino, General Manager of Wageningen Food & Biobased Research

1 Introduction

1.1 General remarks

This report is the result a joint effort between the Dezhou Agricultural Bureau and Wageningen University & Research. It provides an integrated approach to modernise the vegetable industry in Dezhou. New technologies can support modernising efforts but cannot do the job alone. This has two main reasons. First, modernising also requires social innovations and, second, the successful implementation of technologies depends on such things as markets, effective policy support, co-operation between stakeholders and information. All these items are addressed in this report where the technology and co-operation part is covered by Wageningen University & Research (culminating in an advise for a Centre of Excellence) and where the market, information (monitoring and control) and policy goals and ambitions as well as conditions for the process ahead, are covered by the Agricultural Bureau of Dezhou city. The combination of both views and expertise provide an effect strategic guideline for the modernisation of the vegetable sector of Dezhou.

1.2 Basic description of the sector in Dezhou

Dezhou city is a region located to the northwest of Shandong province bordering the province of Hebei. The area has a semi-humid continental monsoon climate. The total population is 5,7 million of which 4,030,000 are employed in agriculture. and the region covers a land surface of a little bit over 1

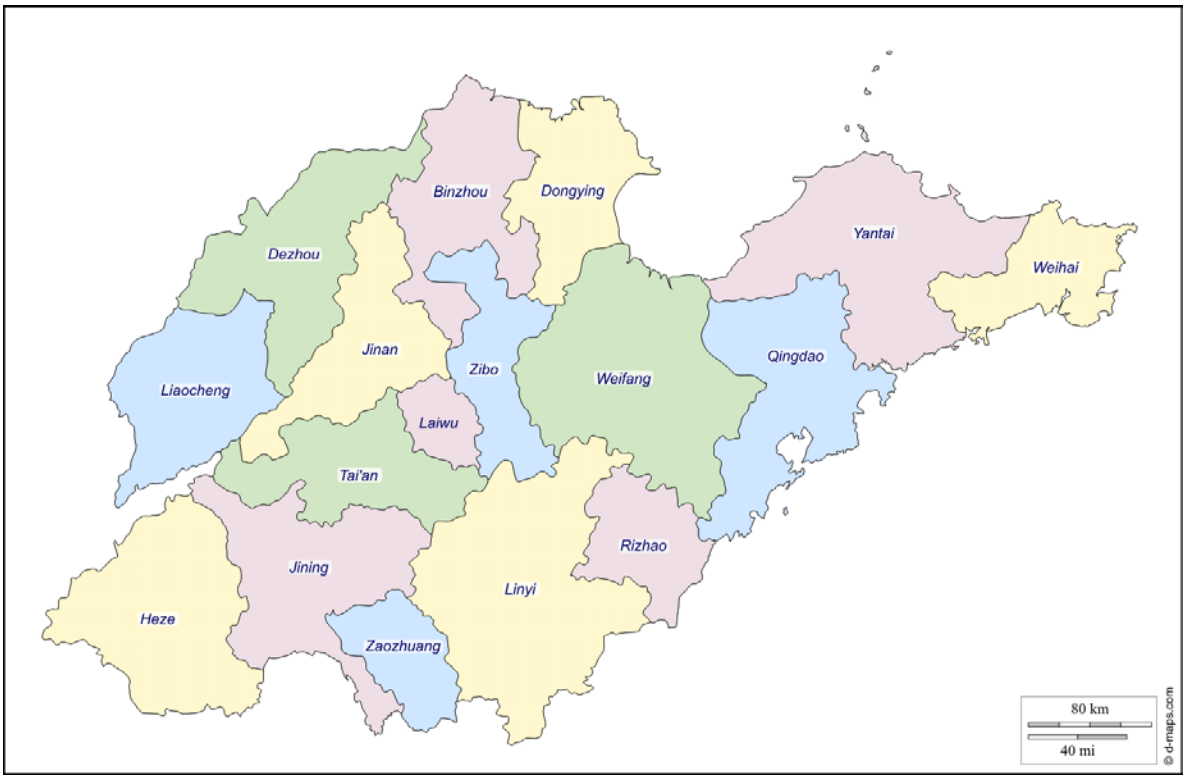


Figure 1. *Map of the province of Shandong.*

million ha. Agricultural land measures around 643,000 ha. About 70% of the population are associated with agriculture. Dezhou is an important production base of wheat, corn, cotton and vegetables. Around 300,000 farmers grow vegetables on an average land area of 0.67 ha, resulting in a total vegetable land area of some 200,000 ha. The production on this area represents 10 million tons of vegetables and a value of over 16 billion Yuan. On average the net income of vegetable farmers is 2,500 yuan, accounting for more than 20% of farmer's per capita income. The city's 8 counties were listed among the key national vegetable production county by the Ministry of Agriculture.

Some 53% of this area is in use for protected cultivation such as plastic film, small plastic tunnels, large plastic tunnels and traditional Chinese solar greenhouses. The net area of solar greenhouse production is 23,000 ha. These greenhouse are suitable for producing temperate vegetables during the winter without heating. These facilities normally have a north-south span of 12-16 meters with an east-west length of about 100 meters. They are mainly used for the yearly production of one long season of tomato, cucumber or zucchini. Tomato is planted in from August onwards until February the next year with first harvests to be expected starting from November until May or June. The same goes for cucumber and zucchini. The smaller plastic tunnels are normally 1-1.5m high and are used for the cultivation of leeks, cabbage and other vegetables. The larger plastic tunnels are normally about 3 meters high and used for watermelon, chili, eggplant, etc.. In these tunnels two crops per year are produced, mainly for early spring and late autumn cultivation. Garlic, Chinese cabbage, celery and radish are mostly planted in open field cultivation. The multi span greenhouse area is relatively small and is mostly used for nursery. These facilities are easy for mechanized operation and large-scale production. In most of the greenhouses plants are grown in soil while a minority is already being produced in substrates. The construction of glass greenhouses is on its way in Linyi County and plans for an additional 29 high-tech glass greenhouses of each 6-7 ha are in execution and planned for the next two years. At present, the first Dutch modern high-tech glass greenhouse of 7 hectare has been realised with an investment of 100 million yuan.

Having the geological advantage of being close to both Beijing (c.a. 300 km) and Tianjin (c.a. 220 km), Dezhou is identified by the CPC Central Committee as an important ecological functional area in the Beijing-Tianjin-Hebei cooperative development. The capital city of Shandong province is laying 127 km to the east of Dezhou. Dezhou serves as an important vegetable supplier of these three metropolitan regions. Eight counties in Dezhou municipality are the state key county of vegetable production, and therefore, Dezhou has the name of “South vegetable Garden” of Beijing and Tianjin, and the “North Vegetable Garden” of Jinan,

The city's vegetable production area layout is becoming more and more developed. Through the implementation of the "one village one product" agricultural development strategy, that has resulted in a number of large-scale, efficient vegetable bases and township. Such as:

- the greenhouse **cucumber** bases concentrated at Wanggaopu and Encheng Town in Pingyuan County, Xiangzhaozhuang Town in Xiajin County, and Chaihudian Town in Ningjin County;
- the greenhouse **tomato** bases concentrated at Linnan Town and Suan Village in Linyi County, Anren Town and Fangsi town in Yucheng City, and Qiancao Town and Zhanghua Town in Pingyuan County;
- the greenhouse **zucchini** production bases concentrated at Lingcheng Town in Lingcheng District and Fangzi Town in Pingyuan County;
- the tunnel **watermelon** bases concentrated at Xindian Town in Yuncheng County, Zhua Town in Qihe county, Wangdagua Town in Pingyuan County, Huangheya Town in Decheng District, andthe small tunnel **leek** bases concentrated by Wangfenglou Town and Wangdagua Town in Pingyuan County and Shiliwang Hui Town in Yuncheng County.

Through extensive corporation with knowledge institutes, universities (research and education) and well-known domestic and international seed companies, more than a hundred new vegetable varieties are introduced and a number of test demonstration bases have been established. At present, 85% of the total vegetable area is planted with high quality seed and seedlings. In total 27 industrial nursery enterprises were established and annual seedling production amounted to 370 million plantlets. Modern technologies in the field of fertilization, CO_2 application, micro-spray, drip irrigation technology, physical and biological control of pests and diseases, seedling production in industrial nurseries, soilless cultivation and other high-tech agricultural applications are expanding.

The large majority of vegetables find their way to the consumer via wholesale markets. At present, the city has 38 vegetable wholesale markets, of which six are approved by the Ministry of Agriculture as the designated national level wholesale market. There are 37 vegetable processing leading enterprises in Dezhou, the major processing products include chili, garlic, radish, onion and edible fungus, mainly concentrated in the city of Wucheng and Leling City. There are 10 leading vegetable agriculture industry enterprises of municipal level, 4 agricultural industrialization leading enterprises above the provincial level and 2 national-level leading enterprises. In Dezhou there are 126 vegetable economic cooperation organizations. The percentage of vegetables produced based on a sales order has increased to 30%. A number of export-oriented enterprises such as Ying Chao Group and Feida Group have developed more than 100 thousand mu of vegetable farms. Qihe Meidong, Yucheng Xiangyang slope, Linyi Xingkang farm and other vegetable companies have realized the initial processing and packaging of vegetables to achieve primary, secondary and tertiary industry integration development.

As part of the Beijing-Tianjin-Hebei co-development demonstration zone, building the "Reassured Farm" for the surrounding big cities has become the main development orientation of Dezhou agriculture. As part of this policy, the city has constructed 314 high standard vegetable parks larger than 200 mu, striving to improve vegetable quality and safety level. Some parks also combine the vegetable production functionality with tourism functions, thus promoting agricultural tourism such as self-picking, renting gardens and other forms. Up to now, the city has more than 300 products with pollution-free, green or organic certification; and has achieved qualification rate of at least 98% in random food safety inspections. Through the integration of the application of modern internet of things technology, modern agricultural high-tech, and primary, secondary and tertiary industry integration development, seven of the vegetable production parks, including Qihe Meidong agricultural science and technology company, Yucheng Xiangyangpo ecological agriculture company, Lingcheng Jinsui wind farm have already reached the Reassured Garden construction standards and became the first group of "Reassured Farms". More than 30% of the vegetable products of Dezhou are transported into the Beijing-Tianjin-Hebei market, creating the brand of safe Dezhou vegetables.

Vegetables in Dezhou are certified in three different categories: pollution-free (harmless), green and organic. The majority of the produce is marketed as pollution-free.

The region produces a large variety of different vegetable crop species. Table 1 gives an overview of the most important crops and their area of production. Various counties and towns tend to get specialized in one main vegetable crop production, several of such specialized counties or town clusters form production bases of, e.g. cucumber, tomato, courgette, watermelon or leek.

Table 1. *Main vegetables produced and the corresponding area (source: Agricultural Bureau Dezhou City).*

crop	area (ha)		crop	area (ha)
cucumber	15,666		leek	6,733
tomato	23,466		kidney beans	4,333
courgette	12,200		Chinese cabbage	8,333
sweet pepper	17,000		Chinese green onion	5,200
eggplant	7,533		garlic	8,533
potato	2,946		onion	986
watermelon	16,000		cabbage	4,953
melon	4,400		carrot	2,600
celery	7,333		bak choy	2,200
spinach	4,600		Loofah	507

The municipality of Dezhou has the ambition to upgrade the vegetable sector considerably. This is described in the 5-year plan of modern agricultural development in the period 2016-2020. One of the aspects of this ambition concerns the increase of the scale of production. An increased scale of production will allow more modern technology to be implemented that aim at higher yields and less use of pesticides and fertilizers will professionalise the value chain with better trained growers and personnel and contribute to improved traceability of the produce. By doing so standardisation will increase and branding opportunities will evolve. In short, this can be labelled as modernization of the vegetable value chain in Dezhou City.

Figure 2. *Product quality of vegetables answered to good standards.*

In recent years, Dezhou City has developed a large edible fungus factory production sector by introducing several leading enterprises such as the Zhongxin fungus industry, Xuerong biological technology industry, Fengyu fungus industry to settle in Dezhou. The Kangrui fungus technology company, Lvtai biotechnology company and other edible fungus local enterprises are also growing fast. The benchmark effect of leading enterprises, promotion by the industrial parks and linkages with cooperatives and farmers have brought the sector into flourish. These edible fungus factory production enterprises make usage of the most advanced technology with the help of industrial and commercial capital investment. The sector has realized high level of mechanization and automation, applied technologies on automatic temperature and humidity control, liquid bacteria methodology, Internet of Things to achieve a standardized, intensified, year-round production. By the end of 2016, the city achieved a total output of 580 thousand tons of edible fungus, with a 3.7 billion yuan output value and $90 million USD export value. The industrial development allowed 56 thousand farmers to increase their income, and has created 11 thousand employment.

1.3 Challenges

Vegetables are fresh and perishable, with high demand of good storage and transportation conditions. The products show seasonal production and usually have a small elasticity of consumption. The input is high while the natural and market risk are substantial. At present, there are some main problems encountered.

Infrastructure is lagging behind.
The vegetable infrastructure is a weak point of Dezhou, seriously affecting the development of production and logistics, easily leading to large fluctuations in market supply and corresponding price fluctuations. The development of water conservancy facilities in rural areas do not meet demand of

newly established vegetable fields and drainage facilities are not at the desired level, often causes yield fluctuation. Greenhouse facilities have low standards and are vulnerable to adverse weather conditions, that intensifies the unbalance between market supply and demand.

Pretreatment, warehousing and cold chain transport is lagging behind.
In the production and circulation of vegetables, there is a problem that the post-harvest treatment is not timely. Field pre-cooling, cold chain facilities are not well established, and the facilities of storage and transportation facilities are lagging behind and the driving distance is elongated. It is difficult to adapt to the fresh and perishable nature of vegetables.

Production and marketing information system is not optimal.
Farmers grow vegetables without accounting for market information and are lacking entrepreneurship. This results in excess supply and corresponding losses and eventually loss of farmer's income.

Vegetable market structure and layout is not perfect.
The basic infrastructure of the markets is imperfect and out of fashion.
The wholesale markets are poorly facilitated, with low level of matching grading, packaging and settling account systems. The city has 38 on-site wholesale markets while local transactions at most production areas.

Brand reputation is not high.
The mechanism for selling high quality vegetables at higher (niche) prices has not really come into existence. There are too many brands and too diverse, lacking of concentrated advantages. Many brand products are traded at general markets, cannot enter the high-end market and cannot become a strong domestic or international brand.

2 Ambition and goals of Dezhou City

This chapter describes the ambition and goals of the Dezhou City region on the future of the vegetable sector based on the existing structure and challenges (chapter 1).

2.1 Ambition

The Dezhou ambition on the vegetable sector can be described as follows:

a) A market demand orientation;
b) A state-of-the-art technology level and innovative;
c) Guaranteed by institutional innovation;
d) Optimize vegetable area lay-out (farm scale);
e) Strengthened vegetable sector infrastructure.

This can accelerate the transformation of the vegetable industry and facilitate the reform of the agricultural supply with efficient energy conversion. With this the construction of the Beijing-Tianjin-Hebei bases of high-quality agricultural products can be supported.

Important features are the enforcement of the quality security system while constantly improving the management specialization, standardization, scaling, intensification, informatization and brand development of vegetable production.

The final ambition is to realize a stable production level serving a safe and reliable quality with low market volatility and hence a controllable system of a modern vegetable industry in Dezhou.

2.1.1 Fundamental principles

According to the Dezhou government the aforementioned ambition should be realised within the framework of some important fundamental principles.

The combination of market regulation and government regulation.
On the basis of giving full play to the role of market mechanism, adhere to the principle of the appropriate government subsidies with enterprises actively participating and investing in farmers.

Use an integral and coordinated approach.
It is important that side effects of possible measures are considered and that the interaction between the vegetable sector and adjacent sectors and developments are taken into account. It is necessary not only to ensure the supply of vegetables, but also to stabilize the grain planting area. It is necessary not only to have a top-level design and doing a good job of planning, but also to respect the wishes of farmers. It is required not only to prevent the market supply shortage, but also to prevent overproduction. It is necessary not only to maintain the overall price of vegetables to a reasonable level but also to protect the interests of consumers, especially medium to low-income residents in urban areas. At the same time, it is important to continue to improve production efficiency and increase the farmers' income.

Capacity building and technological innovation should go hand-in-hand.
A focus is required on the integration of production factors and resource management. Based on the transformation and upgrading of the present day production bases including the planning and realisation of a number of high standards with stable production, quality should be ensured. Further it is important to control and mitigate risks, by balancing production and market demand based on a market early warning mechanism. Also, the capacity of science with adequate technology support is

required together with upscaling, standardization and organization of the vegetable production and the corresponding logistics. In the end, this must contribute to a long term stable development.

Development of production needs to include environmental protection coordination.
It is of utmost importance to actively promote the transformation of production methods, not only paying attention to the improvement of production capacity, but also attaching great importance to the protection of the ecological environment while building environment-friendly, resource-saving agriculture (sustainable development).

2.2 Main development goals

The overall development goals of the development of the Dezhou vegetable markets and supply to cities are:

a) Creating a high level, high quality, high efficiency industry;
b) Implement modern agricultural production technology;
c) Build a modern vegetable industry system to enhance the quality of vegetables;
d) Create reliable vegetable brands;
e) And contribute to the Beijing-Tianjin-Hebei high quality vegetable supply base.

Until 2026, the city's vegetable planting area will stabilize at 3 million mu with a total vegetable output of more than 12 million tons. At the same time, it is the goal to realize a 100% green and/or organic vegetable production, with a high quality and a food safety standard. In 2026 it is the ambition that 60% of the produced vegetables will be post-harvest treated, allowing a total output value that will exceed 20 billion yuan. In 2026, the city's per capita net income of farmers will account for more than 30% of the total net income.

2.3 Specific development goals

2.3.1 Improve market supply.

Through adjusting the structure, increasing production and improving the quality, an adequate supply of vegetables to the Dezhou market will be reached. The average level of yield per year will increase by 2 percentage points or more, reaching 3,700 kg/mu in 2020 and 4,000 kg/mu in 2026.

2.3.2 Reasonable adjustment of structure.

Regarding the planting mode of vegetables, it is the goal to realize the so-called "three hundred" goal:

a) 1 million mu of solar greenhouse;
b) 1 million mu of plastic tunnels;
c) 1 million mu of open vegetables;

Regarding the assortment of vegetables, leafy vegetable production should be increased to better answer to the existing and future demand. Regarding the regional structure, the goal is to gradually reach a reasonable transport radius. Regarding the seasonality, it is important to improve the off-season vegetable supply capacity.

2.3.3 State-of-the-art technology.

It is necessary to equip agriculture with advanced materials, facilities and technologies. Regarding the latter it is much expected from biotechnology, sensor technology, information technology, agricultural products preservation, storage and processing and other modern technologies. This will ensure Dezhou vegetables to reach the leading domestic level in infrastructure, equipment and production technology and other aspects.

2.3.4 Improve quality and brand.

It is of the utmost importance to improve the level of quality and safety of vegetables while meeting the national agricultural product quality and safety standards and national food safety standards. Until 2020, 30% of the vegetable produce will be commercially and professionally marketed and until 2026 this will have reached 60%. On the basis of improving production, it is required to pay more attention to the creation of brands so that in 2026 more than 50% of the sales is under a vegetable brand name.

2.3.5 Improve logistics.

Beside the development of vegetable production and the gradual improvement of the wholesale market, it is important to develop logistics to reach a modern level of cold chain technology throughout the value chain from rural areas into the urban area. This should result in a smooth operating value chain with a high efficiency, low cost and low loss.

2.3.6 Increase farmers' income.

Until 2020, the contribution of vegetables to the per capita net income of farmers in the city will reach 2,800 yuan, and until 2026, reach 3,300 yuan.

3 Goal of the fact finding mission

An expert team from Wageningen University & Research of the Netherlands has visited Dezhou to advice on the modernization of the vegetable production and logistics in Dezhou. The modernization should at first concern food safety but should also consider environmental security in the longer ruin. The advice should consider the long term planning but at the same time advice on modern technologies that could be implemented in Dezhou in the next 1-10 years.

Although vegetable production is the major sector of Dezhou agriculture, the level of production system still has great potential for improvement. In 2016 a delegation from the municipality of Dezhou led by the mayor visited the Netherlands with special attention to the greenhouse vegetable sector. This visit elicited great passion for decision makers of Dezhou to the Dutch greenhouse technologies and the secrete of achieving high efficiency in cultivation. Wageningen University & Research is the core of innovation in Dutch agriculture including greenhouse horticulture. In this investigation the WUR expert team has chosen vegetable sector as a case or example, to develop strategy for upgrade and modernization of an agricultural sector.

The team has taken the Dutch modernisation of the vegetable production in the past 50 years as the benchmark. The so called “Golden triangle” is the collaboration between the government, industry and research and is considered to be the success factor of innovation in the Netherlands. The team has stressed that technology should go hand in hand with co-operation across the value chain and with improved knowledge, training and education and that markets play an important role in the successful implementation of new technology. Thus, propelling the vegetable industry should account for all of these aspects in an integrated and balanced way. This report describes the information collected by the team and the advice on installing a Centre of Excellence that can promote the integration of individual tasks and the required co-operation across the value chain and its enabling environment.

Figure 3. *Supermarket vegetable and fruit department in Dezhou.*

4 Information collected during the fact finding mission

The expert team visited key organisations in the vegetable industry of Dezhou according to the scheme taken up in Table 2. The visits encompassed all steps in the value chain from input suppliers, producers, to local and regional wholesale markets and retail, supported by the Agricultural Bureau which plays a vital role in the enabling environment of the value chain with training, knowledge dissemination and inspection.

Table 2. *Visits to key organisations in the Dezhou vegetable industry.*

Date of visit	Organisation	Role
February 26	Haofeng	Producer of vegetables
February 27	Meidong Group	Retailer of organic vegetables
		Vegetable transport company
	Debai Supermarket	Super market
		Free market
	Agricultural bureau	Support to the vegetable industry, dissemination of knowledge, training, inspection
February 28	Wanggaopu whole sale market	Local whole sale market for cucumber
	Supply shop	Supply of pesticides and fertilizers
	Fangzi squash whole sale market	Specialized wholesale market
	Shouguang Vegetable Group	Plant nursery
	Black horse	Regional wholesale market
March 1	Meidong Group	Producer of vegetables; logistics
	Yiayangpo	Producer of vegetables
March 2	Agricultural bureau	Local governmental agriculture authority

4.1 Important issues learned during mission

4.1.1 Training / knowledge

- Training of farmers (including technical issues and entrepreneurship) and knowledge dissemination is done by the Agricultural Bureau in collaboration with the CAAS and Shandong University. They train around 1,000 farmers each year but more are reached in future with social media such as WeChat. The trainers are trained by the Ministry. The trainers from the Agricultural Bureau train trainers that operate on county level. Also, dragon companies train farmers of co-operative of whom they purchase products for marketing. Some retailers such as international supermarket companies also provide trainings on good agricultural practices according to their standards. The plant protection station of the Agricultural Bureau is also carrying out efficacy and IPM trials on pesticides. Most of these trials are done on farmers

land. Research on new technologies (efficacy testing) is done by the companies who sell the products or technology to farmers.
- Knowledge on the application of biological control agents is complex and lacking of successful experience and help in this matter is welcomed.
- The dragon company supply transplants while giving training on plant cultivation including plant protection.

4.1.2 Production / Farming

- One of the biggest challenges of the Dezhou vegetable industry is the scaling up of the production. The safety of agriculture production to the environment (soil and water including soil and surface waters) is an important issue on the longer run. The skewed age structure of the farmers is also a growing concern. At present 90% of the people working on the land are 50 years or older.
- Dragon companies such as Meidong not only produce products themselves but also buy products from other farmers. For these products it is difficult to have control on or back trace the procedures during the production.
- The region actively works on the upscaling of production. The local government promotes specialized private companies to transfer land from many individual farmers with small piece of land to realize larger volumes of produce. Some 2,5 million mu of land is now in a program that strives at the required upscaling. Land owners are compensated by the land users who manage more and more land. Mechanisation of the production is mostly realised in wheat and corn production but not so much in vegetable production. Yet, more and more of the spraying is done by drones or helicopters.
- The traditional solar greenhouses are effective but are not very much suited to increase the scale of production. In glass greenhouses more opportunities for scaling up come into reach. Yet, energy supply is then increasingly important. Gas, coal, electricity and solar heat are options to meet this demand.
- Open field vegetables are decreasing in acreage but not all will be replaced by greenhouses. Open field crops are rotated with maize and wheat. Protected vegetable production offers more options for food safety and offer more income to the farmer. Yet, it became clear that vegetable prices are considered to be low and offering only marginal financial capacity to invest.
- Much of the agricultural equipment is in the hand of co-operatives.

4.1.3 Supply Chain / Logistics

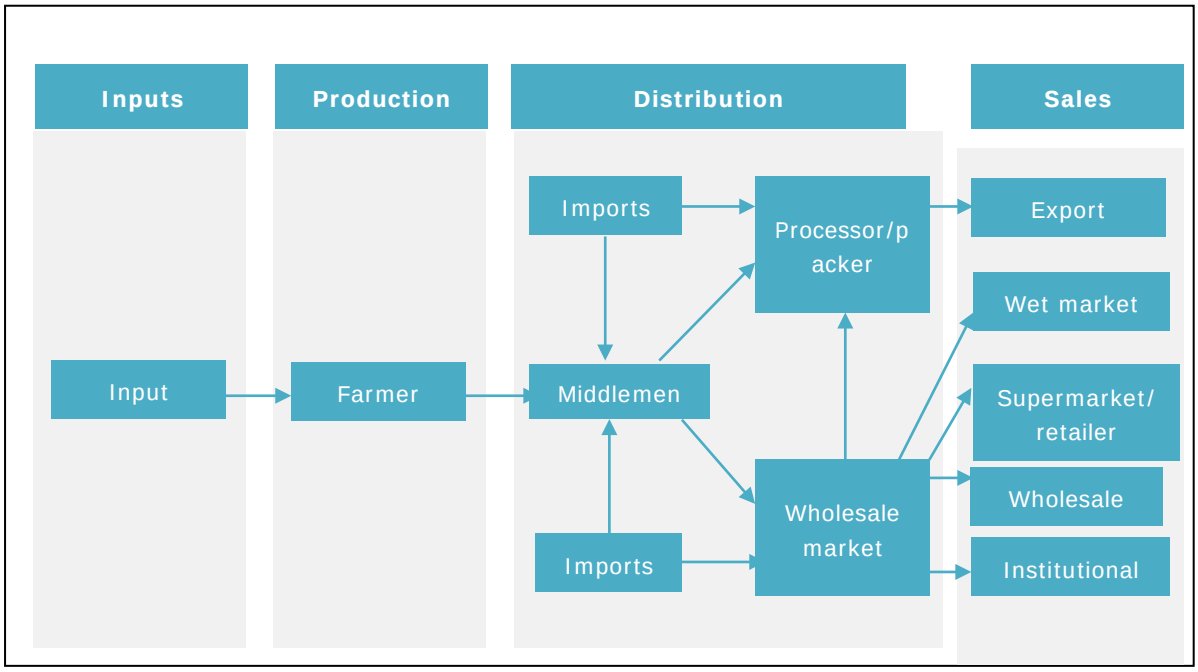


Figure 4. *Schematic overview of the vegetable supply chain in China [Ltd, O.R.a.A.A.C., China pork and broiler value chains. 2015: p. 103].*

The perishable nature of fresh vegetable products requires consumption soon after production. A cold chain increases the shelf life of these products, but in general in China the building blocks of such a supply chain are absent, especially in the case of vegetables, imposing high losses in this food category. China's rapid growth puts pressure on logistics and distribution structures, which is not developing as fast as the market. A typical vegetable supply chain structure is given in Figure 4.

The number of stakeholders is large and it is mainly a push market[1], which are main reasons why there is a lack of coordination in logistics and quality control.
The logistic sector is not only very fragmented also warehousing and storage facilities are behind with respect to technology and size. Transport is an issue as well, since for vegetables 90% is transported without cooling.

Table 3. *Top 10 provinces with cooled trucks in 2016 [presentation on Food Summit, November 4, 2016; Liu Jing, Secretary-General of Chinese Cold Chain logistics League]*

Number of refrigerated trucks per province in 2016[2]			
Province	Refrigerated trucks	Province	Refrigerated trucks
Shanghai	17292	**Shandong**	**4486**
Henan	14075	Jiangsu	3300
Guangdong	7114	Fujian	3269
Beijing	4901	Xinjiang	3204
Hunan	4702	Hebei	1776

[1] Note that these trucks transport mainly meat, dairy, ice cream, fish and frozen food

Remark: in the Netherlands (4x smaller than Shandong and 1/6 of the population) there are 7365 trucks for cooled transport and about 25.000 trailers and semi-trailers [SV in cijfers 2016, RAI vereniging, feiten & Cijfers].

This lack of facilities and cold chain elements is hampering food multinationals from expanding into China's second-tier and third-tier cities.

[1] A push market is a promotional strategy to sell a product on the market. The opposite is a pull market where the demand is central to the strategy and can be more cost-efficient.

- Standardisation throughout the value chain (logistics, standardization of the production technology and process and commercialization of processing such as packaging) is increasing but not yet at the desired level. Branding is considered as being an important concept to reach standardisation.
- Logistics are such that on average vegetables find their way to the consumer within 24 hours after production.
- The larger companies transport their produce in cold trucks (not refrigerated). Most of the produce supplied to wholesale markets is not kept at low temperatures during transport
- Storable products such as potatoes and onions are stored in cold rooms to be able to supply the market with produce the whole year round. This is done by dragon companies.
- For tracking & tracing barcodes are not in use yet, but manual registration of sold, bought or traded produce is common practice. This makes tracing data storage often occurs in physical catalogues which makes tracing time consuming and (real time) tracking almost impossible.

4.1.4 Food safety

- There are three food safety classes of vegetables: organic, green and harmless. Organic products do not allow usage of synthetic pesticides and fertilizers, while green products only allow usage of safe chemicals and the harmless class with non-toxic chemicals. There are national standards for these three categories. For organic and green product labels, the certification is done by the ecological office of the Ministry of Agriculture while the certification of the harmless products is taken care of at the provincial level. Most of the produce is labelled harmless while some 10% is organic. The prices of products per label differ. Green products are half the price of organic while harmless is around 30% of the price of organic. Green production level is around two third of the production level at harmless production.

Figure 5. *Product testing in progress on a regional wholesale market.*

- The inspection centre of the Agricultural Bureau of Dezhou inspects samples at the production sites as well as on markets. They can detect some 50 different chemicals in one analysis. Between 1,000 and 2,000 samples are tested each year. More than 95% of the samples show no detectable residues on the produce. Dragon companies also inspect samples from themselves to monitor their own food safety performance.

4.1.5 Market / Prices

- Price information was received from the Black Horse wholesale market in Dezhou. These were average monthly prices and give a good insight into the price fluctuations that occur on the market. An example is given in Figure 7 for tomatoes. The average price differ 5-fold between the lowest and the highest price. Prices are lowest in the summer period. The cucumber crop shows a very similar price pattern as tomato. For a

Figure 6. *Black horse wholesale market.*

storable product like potato, price differences throughout the year are much more modest: it is not until May at the end of the storage season that the price level rises sharply for only one month. Apparently, in June new products come to the market. Yellow onions appear less storable as prices start to rise from October onwards until May when overwintering onions come to the market.

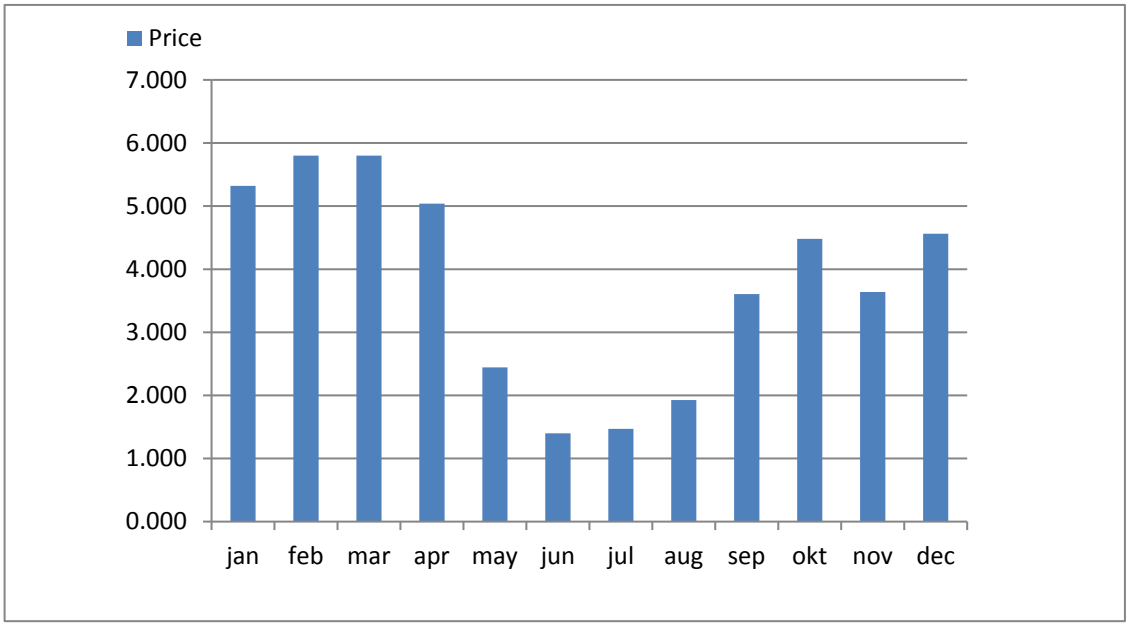


Figure 7. *Tomato average price levels per month at Dezhou wholesale market.*

- Although most of the produce finds its way to the consumer via the local and regional wholesale market, some companies such as Haofeng and Meidong also sell part of their produce directly to retailers (business to consumer) or larger companies as COFCO. Also, they have their eye on new market opportunities with direct linkages to consumers. E-commerce is emerging as a business concept.

5 Future vegetable industry layout

The Dezhou government has formulated a comprehensive policy for the future structural development of vegetable production in Dezhou based on market developments. Below, this policy is described. These desired future structural developments are important inputs to the instruments needed to guide these developments and modernise the Dezhou vegetable industry.

5.1 Major markets outside Dezhou

5.1.1 The regional market of Dezhou

The winter and spring off-season market in the large and medium-sized cities around Dezhou, such as Beijing, Tianjin, Hebei and Shandong province are important to Dezhou vegetable production based on the needs of the consumers. To meet this role, the following is required:

a) Cultivation mode: solar greenhouse, large, medium and small plastic tunnels;
b) cultivation variety: melons, eggplant, watermelon, leek, all kinds of special dishes; product type: fresh vegetables;
c) product standards: highlight the organic and green vegetables;
d) the marketing season: December to May.

At present, Dezhou sold only about 300 millions of vegetables to Beijing and Tianjin, accounting for only about 15% of Beijing Tianjin market share, and there is still great potential of expanding.

5.1.2 Vegetable market in Japan, South Korea and other countries.

For the Dezhou vegetable sector, also the markets in nearby countries are targeted. To meet the challenges of these markets, the following is required:

a) Cultivation mode: open field; cultivation variety: onion and garlic, chili, edible fungus and so on;
b) product type: fresh, dehydration processing; product standards: green food;
c) the marketing period: September to November.

Dezhou is two hour's distance to the Tianjin harbor. At present, several export enterprises such as Yingchao, Spicy Bell, Feida, Lufeng and others develop export produce bases of more than 100 thousand mu. Increase of vegetable export to Japanese and Korean will provide a strong market pull for the export vegetable bases in Dezhou.

5.1.3 Jiangsu Province, Zhejiang Province, Shanghai markets in Southern China.

These markets can be an opportunity for Dezhou using shading facilities to produce eggplant, leafy vegetables, beans and so on. Standard product types can be used: green, pollution-free. The market window is from May to September. Between May and September each year, the southern climate is too hot for vegetable production which makes it an off-season in that area. Dezhou can use protected vegetable production. During the World Expo, the city has two vegetable bases to become the dedicated Expo vegetable bases. Because the vegetables produced in the north are gradually recognized in the south, it is possible to develop 1 million mu of summer vegetables in Dezhou for the southern market with low risk involved.

5.2 Translation of market opportunities to Dezhou area layout

In line with the local conditions, the lay-out is focusing on the construction of an area of 1,050,000 mu with 38 vegetable functional protection areas. The lay-out is based on the ambition of the Municipality of Dezhou.

5.2.1 Pingyuan County

(1) Based on the Wanggao Pu market, develop 50 thousand mu of green solar greenhouse cucumber production bases in Wanggao Pu, Encheng Town; (2) Based on the Qiancao vegetable wholesale market, develop 50 thousand mu of greenhouse tomato production bases in Qiancao Town and Wangfenglou Town; (3) Based on the zucchini wholesale market in Pingyuan Fang, develop 40 thousand mu of greenhouse zucchini production bases in Fangzi Town and Santang Town; (4) Build Wangdagua town vegetable wholesale market to develop 40 thousand mu of large shed watermelon production bases in Wangdagua Town and Taoyuan Ban; (5) Build Wangmiao Town lotus root wholesale market in Wangmiao Town to develop 10 thousand mu of green lotus root bases.

5.2.2 Qihe County

(1) Build Meidong wholesale market to develop 50 thousand mu of solar greenhouse cucumber bases in Xuanzhang Tun and Dahuang Town; (2) Make great efforts to the construction of 50 thousand mu of garlic production bases in Pandian Town and Renliji Town. Establish the leading enterprises and build the Southern Union five garlic wholesale market with resources investment; (3) Make great efforts to the construction of 30 thousand mu of large plastic tunnel watermelon bases in Zhua Town, 20 thousand mu of large plastic tunnel watermelon bases and 10 thousand mu of plastic tunnel melon bases in Huadian Town and regulate the construction of Dabali Town wholesale market; (4) Based on Kangrui, Yishengyuan and other enterprises, build the edible fungus wholesale market in Dahuang Town to develop the development of 10 million square meters of edible fungus base.

5.2.3 Linyi County

(1) Make great efforts to the development of Linna Supermarket to promote 50 thousand mu of no pollution solar greenhouse tomato bases in Linnan Town and Xinglong Town; (2) Make great efforts to the construction of vegetable wholesale market in Suan Town to promote 50 thousand mu of pollution solar greenhouse tomato bases in Suan Town and Linyi Town; (3) Make great efforts to the construction of 40 thousand mu of no pollution zucchini and tomato bases in Hewu Town and regulate the origin construction.

5.2.4 Yuncheng County

(1) Based on Yuncheng Seasons vegetable wholesale market and Zhaoji vegetable wholesale market, develop 50 thousand mu of solar greenhouses tomato bases development; (2) Rely on cheap xylitol, through the specification of bacteria production enterprises, Shiliwang Town develops pleurotus ostreatus production vigorously to strive to high grade, high scale, and by 2020, the scale of production to reach 1 million square meters. Rely on Shenzhuang vegetable wholesale market construct 10 thousand mu of no-pollution plastic tunnel leek bases; (3) Led by Zhangqiao road garlic wholesale market and Liangjialvfeng garlic slice factory, develop 30 thousand mu of garlic bases in Liangjia Town and Zhangzhuang Town; (4) Based on Shagexin watermelon market and Zouzhuang watermelon market, develop 50 thousand mu of watermelon bases in Xindian Town and Dongcheng Ban; (5) Based on the Sijishou vegetable wholesale market, develop 50 thousand mu of solar greenhouse tomato bases, construct 280 thousand square meters of edible fungus bases; (6) Based on Xiangyang Slope organic vegetable demonstration garden, construct 10 thousand mu of high quality vegetable bases for high level market in major city.

5.2.5 Lingcheng District

(1) Build Nanli wholesale market to develop 30 thousand mu of green solar greenhouse zucchini bases in Lingcheng Town and Dingzhuang Xiang; (2) Plan and construct Lvtong vegetable wholesale market in Mi Town and construct 20 thousand mu of solar greenhouse tomato bases.

5.2.6 Ningjin County:

1) Based on the Mengji market and Dongcui vegetable wholesale market, develop 30 thousand mu of solar greenhouse cucumber and 10 thousand mu of plastic tunnel leek bases; (2) Based on the Zhongxing, Lvtai enterprises, develop 10 million square meters of edible fungus Factory cultivation in Ningjin Town and Shiji Town; (3) Based on the Xiluo chili wholesale market in Njingjin Town, construct 10 thousand mu of chili bases.

5.2.7 Xiajin County

(1) Based on the Meizhuang garlic wholesale market, develop 10 thousand mu of off season garlic bases in Baima Lake Town; (2) Based on the Lenong and Younong and other high quality vegetable gardens, construct 10 thousand mu of vegetable bases in Leiji Town; (3) Based on the Wu Town chili city, construct 10 thousand mu of chili bases in Xinshengdian Town.

5.2.8 Wucheng County

(1) Based on the Wu Town chili city and Wu Town Xuandi Temple chili market and Yingchao enterprise, accelerate the development of deep processing of products, develop 100 thousand mu of chili bases in Wu Town, Haowangzhuang Town and Laocheng Town; (2) Based on the Fengyu edible fungus enterprise, develop 10 million square meters of edible fungus standardized produce bases in Lijiahu Town and Laocheng Town.

5.2.9 Leling County

(1) Based on the Yangan Town Seasoning market and Feida enterprise, Pangda enterprise and other leading enterprises, construct 20 thousand mu of chili bases in Yangan Town; (2) Based on the Xisen potato enterprise, construct 10 thousand mu of potato bases in Huangjia Town; (3) Based on the Xinmin vegetable cooperatives, construct 10 thousand mu of high quality melon bases in Huayuan Town, plan to construct vegetable wholesale market in Houzhou village.

5.2.10 Qingyun County

(1) Based on the Fruit and vegetable wholesale market in Qingyun Town, construct 10 thousand mu of green facility vegetable bases in Dongxindian Town and Shangtang Town, construct 10 thousand mu of green Qingyun large leaf parsley brand base in Dongxindian Town, Qingyun Town and Shangtang Town; (2)Based on the Shandong Lufeng food technology company, construct 10 thousand mu of export chili bases in Xuyuanzi Town, Changjia Town and Yanwu Town; (3) Based on the Xuyuanzi vegetable wholesale market, construct 10 thousand mu of no-pollution garlic bases in Xuyuanzi Town, Changjia Town and Yanwu Town.

5.2.11 Decheng District, Economic Development Zone, Canal Economic Development Zone

(1) Developing urban leisure agriculture, based on the Jiulong Bay, Xinqiu, TV University education base, Chunfangyun and other parks, put efforts to develop the leisure planting, harvesting, high quality vegetables, build city sightseeing tourism agriculture; (2) Based on the Heima supermarket and Yanghudian vegetable wholesale market, put efforts to develop suburban vegetable bases, construct 50 thousand mu of Characteristic vegetables bases and 10 thousand mu of watermelon bases in Huangheya Town, Taitou Temple Town and Zhaohu Town; (3) Based on the Xuerong enterprise, develop 5 million square meters of edible fungus factory cultivation.

5.2.12 Smart agriculture corridor

In accordance with the principle of government guidance and market participants, it is important to introduce the Netherlands modern greenhouse technology. The Dezhou policy is to construct 30 smart greenhouses of hundred mu each in the economic development zone of Lingcheng District, Linyi County, Qihe County, Qingyun County, etc. This will contribute significantly to the city's anticipated modern agricultural development.

6 Planning construction priorities

In order to meet the ambitions under the conditions set in chapter 2 and in view of the market opportunities as explained in chapter 5, a number of measures are possible to the goal of Dezhou vegetable industry modernisation in the end. These measures are summed up in this chapter 6.

6.1 Strengthen the vegetable starting material

6.1.1 High quality vegetable seed production.

It is the goal to construct a number of large-scale, intensive, modern seed production bases. Relying on Degao seed, Xisen potato, Tianjin Dreit and other seed companies, make use of available recourses of varieties to select and improve favourite varieties. Around cabbage, melons, potatoes etc., it is the ambition to build or rebuild 10,000 mu of vegetable seed propagation bases in the economic and technological development zones of Pingyuan, Xiajin, Linyi, Leling and other five counties. At the same time, it is required to establish two edible fungus culture propagation bases covering an area of 200,000 square meters in Wucheng, Qihe County. These propagation bases will enable 100 % coverage of qualified starting material in Dezhou.

6.1.2 Promote industrialized nursery.

It is the goal to promote the nursery production to reach a highly specialized and commercial level. In the Linyi, Yucheng and Pingyuan County, build three large-scale vegetable nursery centers with capacity of larger than 30 million transplants. Such nursery centres promote mechanization, automation and digitalization in vegetable nursery production, and will ultimately upgrade the city's 26 industrial nursery companies. Nursery production will focus on integrated cultivation technologies of eggplant, melon species, cabbage and other vegetable seedlings, 80% of the seedling production will apply such advanced technology.

6.2 Strengthen the construction of modern vegetable production bases

Strengthening the production base should entail the cultivation facilities, the production mechanization, intelligent management of production, post-harvest processing, marketing and branding. This should be supported by smart agricultural greenhouses that speed up the efficient use of water and minerals (fertilizers) and by the application of Internet of Things technology. Such technologies will promote the development towards facilitation and intelligence in the vegetable sector of Dezhou city.

6.2.1 Improve the level of production facilities.

The large-scale plastic tunnels with three-layer film plus blanket will be promoted. As for solar greenhouses, tunnel structures shall be improved with application of new materials and methods. This should contribute to improved land use efficiency and increased ability to resist rain, snow, wind and other weather influences. Dutch modern agricultural technology will be introduced to construct 30 "smart agricultural greenhouses" of hundred mu each, which will lead the modern agricultural development of Dezhou city.

6.2.2 Promote the mechanization of vegetable production.

The mechanization of vegetable production entails the use of efficient and modern spraying, furrow ridger, broadcasting and fertilizing, transplanting and harvesting machines will be applied first on damage-less harvesting of leek and chili. Mechanization of vegetable production will be promoted through demonstration.

6.2.3 Strengthen the farm smart management.

Taking into account the "smart agricultural greenhouses" development, to gradually explore the combination of the Dutch smart agricultural technology and the city's greenhouse production while installing intelligent greenhouse water, temperature, gas, fertilizer control systems and mechanized planting. This will contribute to the promotion of the city 's vegetable industry to realize the level of smart agriculture.

6.3 Improve the technical support system

6.3.1 Establish Sino Dutch Centre of Excellence (see also Chapter 8)

It is required to construct a modern agricultural technology Centre of Excellence integrating technical training, experimental research, demonstration and promotion. The Centre of Excellence will have a training room with computer facility, laboratory with analytical and experimental facilities, greenhouse for innovation of advanced technologies, experimental fields for research on new cultivation systems, mobile postharvest laboratory to investigate optimal storage, transport and packaging conditions, as well as sorting and classification of produces. The Centre of Excellence will improve the transformation of the traditional vegetable industry in Dezhou through the research on the optimal design of the greenhouse, production system, precision farming, integrated management of pests and diseases, standardization, track and tracing, and the introduction of mechanization and intelligent technology. This is further elaborated in Chapter 8.

6.3.2 Local technology dissemination

It is important to promote and disseminate technology on local level. To this end, it is required to include all levels of vegetable research departments and technology dissemination departments in the Centre (Chapter 8) and to integrate existing scientific and technological resources varying from supply, technical services, quality control and other aspects of active participation in vegetable functional protection zone construction. Several steps are required to implement:

a) Fully mobilize the initiative of vegetable service personnel. Actively guide the technical staff in-depth production line to carry out technical guidance services, play the leading role of scientific and technological personnel.
b) Secondly, strengthen the training work. Actively strengthen exchanges and cooperation with scientific research institutions, employ experienced vegetable experts, organize technical training, carry out field guidance, and improve the relevance and practicability of technical guidance.
c) Thirdly, increase the intensity of new technology to promote. Introduce fine new varieties of vegetables, at the same time, vigorously promote water-saving irrigation, soil testing formula, improved cultivation, biological control and other new technologies, and gradually equip farms with water-saving drip irrigation, carbon dioxide generator, biogas lamps and facilities, vegetable production machinery and equipment to improve the level of mechanization, reduce labor intensity, standardize the facilities of vegetable technology production operations, guide the standardization and standardization of production.

6.4 Improve the level of science and technology

In Chapter 9, a number of possible technologies are summed up that could contribute to the modernisation of Dezhou vegetable production. It is advised to introduce these technologies via the Centre of Excellence (Chapter 8) and adapt the technologies to the specific Dezhou situation. These technologies are considered accurate for the Dezhou situation based on this fact-finding mission (Chapter 4).

Technologies mentioned in Chapter 8, refer to:

- Smart agriculture greenhouses.
- Solar greenhouse.
- Open field vegetables.
- Agro Logistics / Cold Chain Management

6.5 Construction of a marketing information system

It is important to set up a comprehensive service platform for the information of vegetable production and logistics. To this end, it is urgent to establish an effective information monitoring, with early warning and distribution systems covering all aspects of major vegetable production, logistics and consumption. This will strengthen the analysis and warning of vegetable production, market and price movements, guide the vegetable growers, arrange production and business activities. Firstly, do a good job of pre-production research, understand the consumer demand, predict the market space, guide farmers to produce more market oriented, Instruments could be the choice of varieties and crops, planting systems, make right decision on what kind of vegetables to plant (planning of production at farm level). Secondly, implement a research and development vegetable expert consultation system with online services, to provide timely and effective agricultural technology, agricultural services and give advice to solve questions regarding production. Thirdly, do a good job of market analysis, forecasting and research, establish market early warning mechanism to reduce market risk for business, provide timely and accurate market information services for farmer production and merchants.

6.6 Strengthen the quality and safety of vegetables

6.6.1 Standardized production

Speed up the development of standardized procedures for the implementation of vegetables to strengthen the organic, green, pollution-free food and national agricultural products geographical indications certification. The goal is to achieve more than 20 the above mentioned new certifications per year.

6.6.2 Strengthen quality and safety supervision

It is of the utmost importance to conscientiously implement the "Food Safety Law" and "Agricultural Product Quality and Safety Law" by strengthening the capacity required for an appropriate quality and safety supervision. It is equally important to locally empower the agricultural system in such a way that it will work towards less, better and more responsible pesticide use. High-toxic pesticides should be avoided and replaced by not toxic and more effective alternatives. Local pilots can play a role in this. An adequate monitoring system should be in place to guide the sector in the right way with the ultimate goal of improving the quality and food safety of vegetable products by setting up the right mechanism to do so.

6.6.3 Improve the inspection and testing system

It is important to strengthen the construction of product quality inspection agencies and monitoring procedures and thus contribute substantially to an effective operation of the vegetable product quality

inspection system. An effective monitoring system should be in place based on a reliable sampling methodology. In case of incidents, products should not find their way to the market.

6.6.4 Establish a full value chain trace back system

The basis for an effective monitoring system, is to keep complete records on what inputs used in the vegetable value chain from production to processing and marketing. The origin of products should be able to be traced back in order to identify the source of a quality disorder. The implementation of such a trace back system should be designed and implemented based on the state-of-the-art technology that is available and with the state-of-the-art capacity building.

6.7 Improve the agricultural market logistic system

6.7.1 Improve the wholesales markets

Based on the six markets designated by the Ministry of Agriculture, highlight their leading position, and gradually develop into an yearly trading market combined with direct marketing, packaging processing, chain distribution, transport, warehousing, and e-commerce, becoming a large-scale storage logistics center. At the same time, vigorously develop the 38 vegetable functional areas of the on-site wholesale market at the production area, standardize market management, enhance market functions, from a vegetable market system with complete facilities and complementary functions.

6.7.2 Implement closed cold chain logistics systems.

Around the city's vegetable planting bases layout and logistics pattern, it is required to focus on strengthening the commodity grading, packing, pre-cooling and other facilities to improve the advantages of production areas of pre-cooling and other commercial food processing capacity. It is needed to develop insulation, refrigerated transport, stable product quality and hence reduce losses. At the same time, improve the vegetable cold chain distribution facilities in main sales, develop a centralized procurement, cross-regional distribution capacity of modern vegetable distribution center. Encourage large-scale agricultural products wholesale market, supermarket chains, vegetable circulation enterprises to buy pre-cooling, low temperature sorting processing, refrigerated transport, cold storage and other cold chain facilities and equipment, increase cold storage and other cold chain logistics infrastructure construction, and actively foster impactful enterprises specialized in vegetable cold chain logistics services.

6.7.3 Actively develop the vegetable processing industry.

Firstly, speed up equipment renewal and transformation for the existing vegetable leading enterprises by integration, transformation, upgrading, focus on health food, snack food research and development, promote high scale, high grade, high level enterprises, give full play to industrial resources. Introduce a number of well-known processing enterprises with strong driving force as soon as possible, and actively guide them to set up production bases, develop order-based production, enhance export of processing vegetable products. Secondly, strengthen the production and marketing docking. Guide the wholesale chain of agricultural products to extend the operating chain upstream and downstream, and establish sale relations between agricultural production bases and retail customers to direct purchase, carry out distribution services toward groups and supermarkets; support large supermarket chains and farmer professional cooperatives to carry out "agricultural supermarket docking." Put efforts to expand the docking scale, and strive to realize the proportion of vegetables sold by supermarket reaching 50% until 2020. Thirdly, further introduce and standardize e-commerce transactions.

6.8 Develop and expand vegetables brand

Make the "Reassured farm" construction as the starting point, vigorously carry out brand promotion, product sales and other promotional activities, enhance brand awareness and market competitiveness of vegetables. Strive to bring "Dezhou watermelon", "Qingyun coriander" and other traditional characteristics brands bigger and stronger, bring the "Lingxian" zucchini, "Gaopai" cucumber, "Qiou" tomato, "Dongcui" leek and other local products into well-known brands. Through the unified registration, publicity, packaging, standards, and further integrate resources, focus on cultivating, to create the Dezhou regional vegetable common brand, to create a number of high market share of "De" size vegetable brand. To 2026, nurture more than 10 well known domestic and foreign vegetable brands, to create a gathering well known vegetables band place.

6.9 Strengthen policy support

6.9.1 Support facility agriculture development

Firstly, support the development of smart agriculture greenhouses. Loan discount subsidy on the new-built hundred mu of wise agricultural greenhouses. Secondly, support the development of solar greenhouse. For the new development of solar greenhouse construction of the main body, according to the difference in the development area, give different incentives. For the new bases of over 500 mu area, coordinated by the county government, build 4 meters wide cement road connected with the main road, to achieve water, electricity, road links. Thirdly, support upgrading of production. Reward scale to promote the use of resource efficient water and fertilizer technologies, implementation of IT solutions such as Internet of Things or others and the renovation of vegetable greenhouse facilities. Fourthly, credit support. Promote "family loans" to solve the problem of the yearly solvability problems of farmers. It is envisaged that farmers can access loans of 100 thousand yuan to support the development of new or adapted facilities for vegetable production.

6.9.2 Support the enhance of the quality of agricultural products

Firstly, improve the three product certification rate (see Section 6, point 1). For the newly obtained non-polluted agricultural products certified by the Ministry of Agriculture, green food, organic food can be subsidized by 50% of the cost of certification. Secondly, support the standardization of production. Support the standardization of production system construction, support pest and disease integrated management technology research and promotion. Thirdly, support the establishment of back tracing system. The government put special funds to build agricultural back tracing platform to promote the use of radio frequency identification and near field communication proactive identification technology.

6.9.3 Promote the development of vegetable brands

Firstly, support development of well-known trademarks and brand-name agricultural products. Special funds are invested to support vegetable enterprises and cooperatives to declare China's well-known trademarks and Shandong Province famous trademarks; support the declaration of national agricultural origin protection signs, agricultural products geographical indications trademarks; support the declaration of national and Shandong Province brand-name agricultural products. Secondly, promote market development. City finance expends special funds annually, specifically for the regional brand planning and design of the region, the Beijing-Tianjin-Hebei market display of products, conference promotion, media promotion and so on.

6.9.4 Integrate financial agriculture projects for concentrate investment

Integrate financial funds for agriculture to support the greenhouse and tunnels other infrastructure construction of water, electricity, roads etc., develop agricultural products processing, leisure agriculture, rural tourism and other industrial integration projects; support project funds for poor households by dividends to participate in greenhouse construction.

7 Safeguard measures

7.1 Organizational embedding

Earnestly strengthen the "vegetable basket" mayor responsibility system, set up the leading group consisted of the mayor as the head, the county (city, district) and the city directly related people as the members, responsible for the strategic planning organization and implementation, work deployment, management coordination, inspection and supervision of industrial construction.

7.2 Policy implementation

Each city, county (city, district), town at all levels should put developing high quality and safe vegetables into the financial budget, and with the growth of fiscal revenue increased year by year, the vegetable demonstration park and base, market infrastructure construction, quality control, technology research and development and promotion and other aspects of key need to be supported. Agricultural comprehensive development, agricultural machinery subsidies, farmland water conservancy projects, modern agricultural projects and other projects tilt to the high quality and safe vegetable bases. Through the establishment of close base leading enterprises, increase the capital investment in the base construction. Encourage bank financial institutions to increase credit support for vegetable production, improve the variety of vegetable insurance, and actively guide farmers to insure. At the same time, actively introduce and use foreign capital, strive for and mobilize social funds, increase investment in the vegetable industry.

7.3 Science and technology support

Absorb the famous vegetables experts in- and outside the province as members, organize Dezhou high-quality safe vegetable expert advisory group, responsible for the construction of high-quality safe vegetable base technical guidance work; highlight the Sino Dutch Center of Excellence, do the introduction and transformation of technology; carry out technical train of the agricultural technicians at all levels and farmers, draw up specific measures for technical popularization, organize the integration of advanced agricultural technology achievements, select fine varieties, arrange test, demonstration, and promotion work.

7.4 Assessment of incentives

Establish a sound assessment system, and establish a comprehensive assessment system including organizational leadership, financial investment, inspection system construction, product certification, brand creation, agricultural management, routine inspection, market access and so on, into the city's comprehensive scientific development comprehensive evaluation system. Combined with the "vegetable basket" project, break down the planning task objectives into the county, district, town and relevant departments, and quantify and refine further to strengthen supervision, strict the assessment of incentives to steer the development on the desired route.

8 Benchmark: agricultural development in the Netherlands

Modernization of agriculture will require the introduction of many technologies that are new to the farmers and companies implementing them in their business. To make this work, technologies should match the local situation. If the match is not good, implementation of new technology can potentially lead to (financial) disappointments. The reason for this is that there is a difference between innovations and technology. It is important to consider this when modernizing agriculture in Dezhou or anywhere else in the world. Modernization requires innovations that are sometimes based on new technologies. Technology can lead to innovation while innovation depends not only on technology. Successful innovation in agriculture depends on several factors that are more or less determining the outcome of innovation attempts. These factors are:

- Knowledge: it is obvious that new knowledge underlies innovation and that knowledge is needed to apply new technologies. Knowledge can come from education, from vocational training, from demonstrations, from farmers and from suppliers etc.
- Markets: technologies can only pay off when it is supported by the markets, especially when technologies raise the cost price level. Also, markets should accept the production process that is applied, so including technologies used. Markets not only pay for a product but also set conditions under which production is realised.
- Co-operation: this factor is increasingly important when more knowledge or technology sources are required to implement the innovation. For instance, a greenhouse can be considered a technology that require sellers and buyers but also maintenance expertise. Without co-operation modernization is unthinkable. And this puts forward the importance of good and effective communication.
- Physical infrastructure: This factors refers to roads and other infrastructure (such as data or energy). Glass greenhouses that need energy are dependent on the availability of energy that for instance comes from grids. This innovation factor could also refer to the size of farms and the scale of production.
- Legislation and regulation: it goes without saying that these instruments have an important aspect in what innovations take place because they set the boundaries and conditions for the development.
- Values, norms and symbols: these are more “soft” factors but very important in innovation. Take risk perception as an example. The first farmer or company to apply a new technology can perceive a higher or lower risk. Some farmers or companies first want to wait and see. Others are more innovative and take higher risks in the expectation that it will pay off to be the first or among the first to implement a technology. There is also the factor of believing that an innovation will be effective. Demonstrations often have a function in this success factor.

In the Netherlands, modernization and industrialization of agricultural production and storage from 1900 onwards was at first highly supported by close collaboration between organisations for knowledge dissemination, education and applied research (at experimental research farms). This is commonly referred as the OVO triptych which was initiated, financed and managed by the government. After 1950, modernization in Dutch agriculture and food production was more and more characterised by increasing scale of production, more mechanisation, land consolidation and technologies on greenhouse management, fertilisations, crop protection and others. It is generally recognized that the close collaboration in the OVO triptych has much contributed to the successful transition of Dutch agriculture to a modern and industrialised sector that nowadays is very important for the Dutch economy (10%). The OVO triptych has functioned as an innovation engine in this period and was concerned with many of the above success factors such as knowledge, co-operation and values, norms and symbols with effective linkages to legislation and regulation. The nucleus of the model were the research farms that were situated very close to farmers, thus representing their own

production environment. This is important as the exact shape and application of technology can be different from one region to another. For instance, farmers on sandy soils trust variety comparisons on their type of soil more than those carried out on heavy clay soils and vice versa. This can result in one variety matching local conditions on sandy soils better while another variety appears to be more appropriate to clay soil conditions. Also, in some regions typical crops are being produced while in other regions other crops predominate. This requires technologies to be slightly different from one region to another. Applied research close to and in continuous information exchange with farmers can help shaping the innovation and thereby support implementation and application. Thus, applied research fills the gap between science and practice. New knowledge and technologies are tested and are shaped to increase the match and promote the success of innovation. The concept also works the other way round: farmers can bring forward their problems, ideas for innovations and questions and can thus influence science and the development of new knowledge and technologies.

In the Netherlands, applied research was managed by government and companies together. So co-operation between them was at the heart of the concept. Nowadays, applied research is still very important in the Netherlands and many companies and farmers co-operate with applied research to meet their needs and help shape and implement technologies. Companies and applied research co-innovate to bring new technologies to work. These can be very diverse companies, both upstream and downstream from the primary sector. Supply companies test their products to make sure their effectiveness is proven vis-à-vis benchmark products. Processing companies need the knowledge of applied research specialists to test new ideas and create new technology.

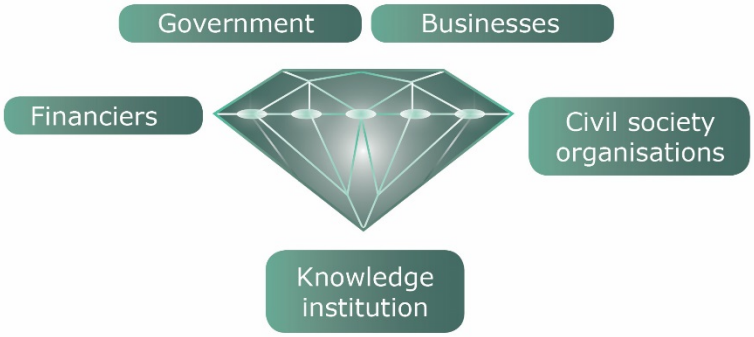


Figure 8. *Dutch diamond concept in agrifood development.*

However, to modernize agriculture and bring about successful innovation, the private sector always has played a very important role. Therefore, in the past 20 years farmers and private companies have joined the co-operation model more and more. It is for this reason that the OVO triptych has been replaced by the so-called diamond model (Figure 8). To make sure modernization is also supported by society, non-governmental organisations, are also included in the innovation process as sustainability has become a very important aspect of agricultural modernization.

It is good to stress that the Dutch OVO triptych or the Dutch Diamond Approach cannot be translated to another environment without fine tuning it according to the local conditions of the target country.

9 Propelling Dezhou vegetable supply chain development

9.1 Centre of Excellence

Off course, many technologies (see chapter 6) are available to help modernizing Dezhou horticulture and uplift the sector to meet EU standards. Each of these technologies can play a vital role in this ambition. However, technologies should be developed tailor-made to fit the local situation, training should be supplied to understand and use the technologies and technologies should be implemented in practice. To do so, an effective organisational infrastructure should be available. The question is what organisational vehicle could be effective in bringing these technologies forward to innovate the Dezhou agriculture? The aforementioned 5-year plan of Dezhou City mentions science and technology as being important and also stresses the need to co-operate to bring the vegetable industry to a higher level.

It is the opinion of the expert team that applied research can play a vital role in this ambition. Applied research will enable the optimal support of technology implementation not only by providing test results and by organising demonstrations (best practices), but also by organising co-operations between private companies, farmers and the government. But applied research should not be isolated from other knowledge driven support systems such as dissemination and training. This is a lesson learned from the Dutch innovation model as described in chapter 4. There should be strong co-operation between the different functionalities generating win-win situations. Trainers need to be involved in innovation processes as soon as possible to be able to play a role and to learn from the technological progress. Linkages to education and university research should be set up to promote the newest knowledge to be implemented without delay. Also, linkages with private or Dragon companies are required because it is in their interest and in the interest of farmers and society that the best products are used in the best way and the best timing. To ensure this, it is important to uphold scientific principles to carry out independent research with state of the art data acquisition, sensors and facilities. This could be the task of a Centre of Excellence. This is the place to witness innovation and to be part of the modernization transition. The Centre will bridge the gap between science and practice. Thus, the Centre can put science to work.

This Centre should not replace existing practical knowledge driven support systems, but should integrate them in one organisation, sharing state-of-the-art facilities and embedded in active networks with universities, companies and the government as depicted in Figure 9.

The main activities of this Centre will be:

1. Training: training activities are carried out by the existing knowledge dissemination structure in the region. This should not be duplicated. Rather, concentration could be considered as this will create a win-win situation with other related functionalities.
2. Demonstration: for farmers and producers and other companies it is important to exchange information and to absorb new information. This should be facilitated by organising events where applied researchers show their results (best practices) and companies their latest products (varieties, fertilizers, crop protection agents etc., etc.) in demonstration plots. Downstream activities should be included such as storage, grading and processing.
3. Applied research: as indicated before applied research is the last step from development of technology to implementation in practice. The next step would be that the first farmers would apply the technology on their own crops and land or that the first companies will apply the technology in their process. To do this, the Centre needs to have appropriate facilities at their disposal such as laboratories, open fields, greenhouses and (cold) storage rooms.

The facilities of the Centre should enable the Centre to function properly and to make sure that it is reliable using state of the art equipment so that results are considered to be in accordance with what

farmers, and companies expect. This will enhance the implementation of knowledge and results. Facilities that the Centre would need, are:

- Rooms for training with computer facilities. Also e-learning facilities should be available.
- A laboratory to analyse samples from research. These can be soil or product samples. Here it is important to make maximal use of facilities already available in the region to prevent duplication.
- Greenhouses: different types of greenhouses should be erected with small size but large enough to result in reliable results.
- Open fields: these fields should be large enough to rotate crops in a way that soil effects of trials are eradicated when new trials are laid out on the same field in later years. Equipment should be available with the same effect that machines in practice will generate. A nursery need to be included to allow the Centre to do applied research on the seedling raising as well.
- Storage rooms (cold) to store the most important products for shorter or longer periods depending on the usual storage periods in practice but also for being able to better match demand and supply (flattening of supply peaks). Also, grading facilities are required because for vegetables it is not only about yield but also about product quality in relation to shelf life.

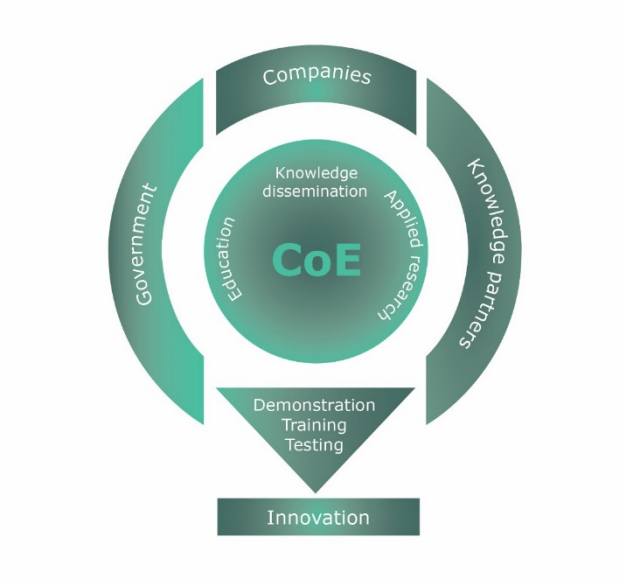


Figure 9. *Concept of the Centre of Excellence in Dezhou region.*

The governance of the Centre should be in co-operation between the government and producers and downstream processing or trading companies. It is crucial to organize the voice of the local growers in the planning of the research agenda and the guidance of the applied research projects. Co-operation with government is possible as long as there is a common goal regarding the development of the agrifood sector. Food safety, productivity and sustainability are in the interest of all involved and this is the common ground to develop work plans for the Centre. It is also possible to educate Chinese researchers to conduct applied research which benefits both private goals of farmers and societal goals of government and citizens.

The activities of the Centre should follow a yearly planning-operation-evaluation scheme. In this way, items are addressed that have close links to the problems and perspectives regarding the implementation of technologies. It is of the utmost importance of the Centre to set up close communication with farmers, co-operatives and companies. Part of the communication strategy can be the consideration whether or not demos will be developed in regions with deviating conditions. In doing so, knowledge and innovation come close to farmers and companies which will contribute to the implementation process.

Most important for the success of the Centre would be the specialists and experts that manage and carry out the applied research trials, and acquire and interpret the data. They need to train the

trainers and be responsible of quality of the activities of the Centre. Exactly what expertise is needed, will depend on a prioritization of the activities of the Centre.

The financing of the Centre should ideally provide a long term funding as the centre needs time to become effective. It is proposed to provide a funding of 5-10 years. At the same time the percentage of funding by farmers and companies could gradually increase in importance with a simultaneous decrease in government funding. This will increase commitment of the private sector and will promote that the activities of the Centre will meet the demands raised by the famers and companies.

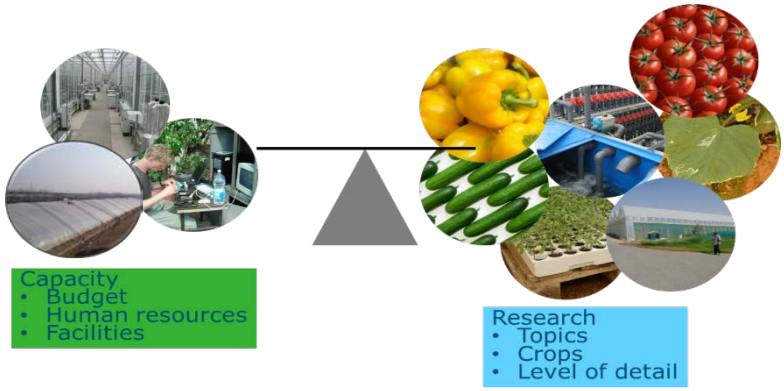
Human Resources are a key factor to success. Amongst the knowledge and competences needed are know-how on experimental design and analysis and a thorough knowledge of the innovations to be addressed. Also, operations of sensors, software and laboratory equipment require proper attention. Therefore, we recommend staff training programs to be developed and implemented that match the personal needs of the people working at the Centre. Part of the implementation could be done in the Netherlands and part in China.

Finally, it is advisable to organise yearly reviews of the activities, progress and results by the Centre. An advisory committee representing the government, farmers and processing or logistic companies should be appointed to fulfil this task. To make these reviews effective, it is advised that the management of the Centre defines a number of deliverables and milestones with which the impact can be quantified.

9.2 Planning

To implement and support the functionality and the success of the Centre of Excellence, the following planning is advised:

Step	Timing (year from now)	Content
1	0	Detailed planning of the Centre of Excellence. Items to be addressed are: • Identify and appoint a project manager who will co-ordinate the process of design and establishment of the Centre of Excellence (CoE). • Define the main items to be addressed by the CeE in accordance with the requirements of the modernisation of agriculture in Dezhou such as crop protection, food safety, fertilisation, greenhouse technology, cold chain management etc. • Determine what existing Dezhou organisations need to be merged into the CoE. • Define the roles of the CoE: research, training, advise and demonstration. • Define the facilities needed. An impression of this is given in paragraph 5.3. In general, facilities are needed for greenhouse and outdoor cropping, (cold chain) logistics and storage. Parallel to this laboratory facilities need to be identified as well as machinery for soil cultivation spraying and harvest. • Define the human resources required to carry out the tasks of the CoE. • Define and set up the governance structure of the CoE. The governance structure (the board of CoE) should guarantee that the CoE carries out activities that are most efficient and effective in aiming for the modernisation of agriculture in Dezhou. The governance structure should cover the interest of all Dezhou stakeholders involved: government, farmers, private companies, fundamental research institutes. • Define and set up an expert group that advises the Board on the projects that are set up and the products to be produced. The expert group reflects the stakeholders that will implement the results of the CoE on farm and logistic level.

		• All activities in the CoE are organised in projects with a goal and a budget. An arrangement for planning and evaluation of projects should be defined and installed.  The above figure illustrates the importance of a balance to be established between the capacities available and the research demand. This support a good project management and prioritisation of issues to be addressed. If required, Wageningen University & Research can support the project manager in his or her activities and tasks.
2	0-2	Capacity building of the human resources. This is a training program for the staff of the CoE. Training items are: • Experimental design and analysis: this concerns the lay out and operational aspects of experiments. This is not only a training for researchers and technicians but also for staff working in the fields and greenhouses. • Facility maintenance and use: this is especially important for greenhouse technology, logistics technology, storage facilities and machinery. Wageningen University & Research is able to develop tailor made capacity building and training programs which could also include training sessions in the Netherlands.
3	1-5	The first 5 year period is used for applied research. This means setting up experiments, collecting data, analysing the data and translating the data to concrete products that will be helpful for practice. It is advised to make a research agenda for this 5 year period that addresses the priority crops to be researched and the main items in these crops as well as the main items in the value chains (f.e. logistics, materials handling, packaging and (cold) storage). The governance structure as developed, applied to the operations in this period. This 5 year period is required to develop best practices for the priority crops and the required logistic technologies. During this period, demonstration days will be organised at which companies and farmers are invited to learn the latest results and visit the trials. The role of Wageningen University & Research could be limited to support of the research, interpretation of the results and advise on the planning for the next year.
4	6-10	This period is used for the next step in spreading the results to and implementing in practice. For this period farms and companies are selected that will be guided and coached to apply the best practices (satellite farms). These farmers should have a leading role in their region. This supports the acceptance of other farmers to implement the results on their own farms as well.

		This period is required to implement an evaluation and learning cycle in the satellite farms. Twice a year each satellite farm is visited and evaluated, Also, the planning for the next period is discussed. Each year, farmers in the region/area surrounding the satellite farms are invited to visit these farms and learn from what they have done. Parallel to the satellite farms, the applied research in the CoE continues. Now, the experiences of the satellite farms are used as input in the prioritisation of the projects of the CoE. On turn, the results can be directly implemented in the satellite farms.
5	10-15	In this third period, the results should be wider disseminated amongst the farmers and companies. This can be done by setting up networks with many farmers. These networks will organise field or greenhouse or company meetings at several participants, discussing their plans and results. Each network should be supported by an expert from the CoE. Again, in this period applied research continues and the network information will be used to prioritise the research and activities (demonstrations) of the CoE.

9.3 Facilities

As indicated before, facilities are of prime importance. The facilities are used for applied research and will be used to demonstrate new knowledge and technologies. This paragraph gives an insight into how facilities could look like and what technologies could be incorporated in the Centre of Excellence (CoE).

9.3.1 Open field research and demonstration facilities

Applied research on open field vegetables requires an area of at least 20 ha of land that is divided into 5 equal fields of 4 ha. One of these fields is grown with a recovery crop (such as alfalfa) that is need to restore soil fertility and erases the soil effects of the experiments. The other four fields are used for field experiments of different groups of crops: cabbage crops (Brassica species), leafy vegetables, pulses or others. The five fields are rotated each year to prevent soil diseases to build up their populations. The exact rotation determines on the soil health of the area chosen and on the crop groups that have the priority. Machinery is needed to cultivate soils, harvest crops, spray the fields and fertilize the crops. As crop surfaces might be small, it is important to have machinery available that can work on rather small scale. As shown in Figure 10 machinery should permit small plots of a relative small field to be shown with different varieties or different seed treatments. Also spraying should permit different products to be applied at the same time to mitigate the influence of fast changing weather conditions.

Figure 10. *Sowing machinery for field experiments.*

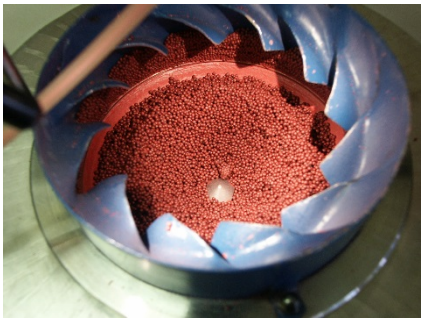


Figure 11. *Seed treatment.*

Depending on priorities identified, a seed treatment facility could be important. With seeds, tailor made plant protection and fertilisation applications can be researched and developed (Figure 11).

Figure 13 show an example of a field experiment. This gives an impression of how it could look like.

Figure 12. *Field trail.*

A nursery is required to produce seedlings for the experiments. This can be done in a greenhouse. The planning of producing seedlings and planting crops needs to be tuned to a high extent.

If the Dezhou region has different distinct soil types, it is recommended to have experimental farms on different locations in Dezhou region. This is important as different soil types may require different best practices to be developed or may require different aspects to be researched or prioritised. For instance, soil disease can completely different and fertilisation should be tuned to the fertilisation level of the soil (clay versus sand).

9.3.2 Greenhouse facilities

The activities at the CoE on greenhouse technology should ideally focus on topics like climate control, irrigation and nutrient strategies and soilless culture, crop management and Integrated Pest Management. The research will be focused on adapting available technologies to the local conditions.

We propose to build a greenhouse facility consisting of at least 12 compartments within a high-tech glasshouse (Venlo type). Each compartment has an equal surface of about 100 to 150 m^2. Installations are a.o. heating, (LED) lighting, screens, air humidification, and hanging gutters with substrate and drip irrigation (although in some compartments, cultivation in the soil must also be possible). In each compartment, the greenhouse climate and water and plant nutrition can be controlled individually with process computers. Sensors are needed for measuring conditions inside and outside the greenhouse (e.g. temperature, humidity, radiation). ICT for data collection, data processing and data distribution. For research on pests, it must be possible to prevent insects and mites to fly in or out the greenhouse.

Figure 13. *LED light experiment.*

Some additional laboratory facilities are needed for cultivation experiments (weight, length, leaf surface etc.), crop protection research (e.g. binoculars, PCR), soil and substrate (physical and biochemical analysis).

This glasshouse facility is mainly meant for high-tech greenhouse applications. For mid-tech greenhouse research, it can be an option to build solar greenhouses (at least two, so comparisons can be made). In these solar greenhouses, the potential of applying new techniques in more traditional greenhouses can be explored. For instance soilless cultivation and computer based climate control.

Figure 14. *Soilless cultivation in a solar greenhouse.*

9.3.3 Tracking and Tracing research and demonstration facilities

The system of and the technology related to Tracking & Tracing, i.e. the process of determining the current and past locations (and other information) of a unique item or property within the supply chain, is well developed and widely available as are best practices. However, the growing number of recall incidents, for example in the food chain, let to new solutions, technology and tools going from the passive identification like barcodes, QR codes or even Radio-frequency identification (RIFD) to active identification using RIFD and Near Field Communication (NFC). Active identification not only gives the possibility of a real-time locating systems (RTLS) to automatically identify and track the location of the products in the supply chain. It also makes it possible for products to communicate

their status, not meaning location. For example, food products of which the quality decay goes faster due to temperature abuse could send a signal to the suppler, buyer, logistic service provider giving the opportunity to act on it.

Especially the system approach described above could be demonstrated in the Centre of Excellence. Using the setup of a practical exhibition and explanation of how this concept works or is performed using the existing technology and best practices in the world will show the food industry the possibilities and the impact on food quality and food safety.

Figure 15. *Examples of demonstration site showing RFID Tracking & Tracing in the supply chain of fresh cut vegetables (Source: Project Versschakel).*

Also new tags can be demonstrated like the so called Pasteur Smart Sensor tag, a stand-alone, wireless sensor tag, developed by NXP Semiconductors, Wageningen UR Food & Biobased Research and many partners.

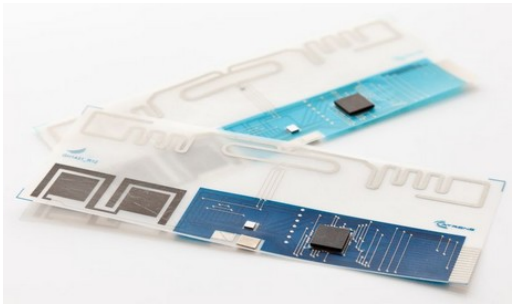


Figure 16. *The new RFID Pasteur tag as example of new technology to be demonstrated in the centre of excellence (Source: Wageningen Food & Biobased Research).*

This tag, is a tag based on NXP's UCODE I2C and funded within the EU Pasteur project and tracks the geographical origin of a perishable and the history of conditions under which it has been handled, stored and transported. Wageningen UR developed detailed quality evolution models for various products, such as meat, fresh-cut roses, etc. Using these models, the tag is able to translate the recorded data into an accurate prediction of the perishables' quality and remaining shelf-life. (*source: https://nxp-rfid.com/pasteur-smart-sensor-tag-based-nxps-ucode-i2c-wins-food-valley-award-2013/*)

9.3.4 Cold Chain research and demonstration

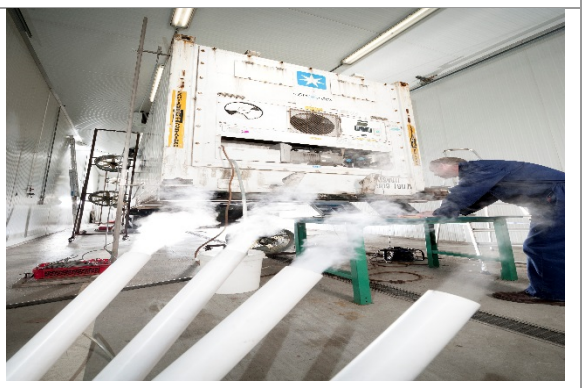
Solutions to create optimal transportation, storage and packaging conditions for fruits, vegetables and flowers could be researched and visualised within the Centre of Excellence. Showing the impact of conditioning, especially controlling the (right) temperature from field to fork on the food quality and the shelf life of food products will help working towards the implementation of the needed facilities in closing the cold chain. The demonstration site should represents a large investment needed for onsite demonstration of the Centre of Excellence achievement in an operational environment, but also a show-room for innovative technologies related to cold chain optimisation coming from different actors.

Research and demonstration can go hand in hand. Simulating the supply chain and researching the right temperatures, or validating the temperature regimes available in literature for the specific Chines situation gives also the opportunity to show the facilities and the results.

In a later stage also the combination of product, packaging, transport modalities and temperatures could be researched and demonstrated.

The Demonstration site will significantly enhance the (open) innovation activities, working as a show room where for example innovative companies can showcase and actively implement their solutions, while researchers from the centre of excellence and other collaborating institutes can run the experiments and advanced cold chain improvements.

Table 4. *Examples of small and large(r) scale testing and demonstration options related to the cold chain (Source: Wageningen Food & Biobased Research).*

Small scale (laboratorial) testing	Large scale (real life) testing
	
	
	
	

10 Technology innovation examples

This chapter presents a selection of technologies that can assist Dezhou agriculture to modernize its operations and results. Some of these technologies can be easily implemented while others require more R&D efforts. In all cases, these technologies could be incorporated as activities in the Centre of Excellence. This can be training, demonstration or research. This chapter also serves as an inspiration when considering improvements in Dezhou agriculture and agrifood chains. The examples relate to greenhouse production, field vegetable production and logistics. For each of these examples, comparable information is included:

- Description of the technology
- Expected impact on product quality and food safety
- Key factors for successful implementation
- The time to innovation: an indication whether or not short term implementation and impact van be expected.
- Role of the government

Our mission was restricted in time and thus the number of companies and organisations visited. This will have limited our view on the state-of-the-art of technologies in Dezhou agriculture. As a result, some innovations might already be used and can thus be ignored regarding the Centre of Excellence.

Greenhouse production: optimal greenhouse design		
	Description	In Dezhou area, protected horticulture is mainly done in plastic tunnels and “solar greenhouses”. Production capacity and quality (food safety!) in these greenhouses is limited. The ambition of Dezhou is to build several Dutch style Venlo greenhouses with glass cover. The challenge is to design greenhouses, adapted to the local circumstances in Dezhou. Climate conditions, but also infrastructural conditions (energy, water, CO2, logistics) and socio economic factors (knowledge level, labour capacity, demands from markets) determine the optimal design. The design of the greenhouse itself doesn’t have to be a very radical innovative design; the innovation can also lie in combinations of proven technology, e.g. a Dutch type glasshouse with energy from a solar power plant.
	Expected impact	Greenhouses adapted to the specific local conditions: climate, infrastructure, socio-economic aspects, have a much higher change to succeed in the long term.
	Key factors	The tools for Adaptive Greenhouse Design exists. We have made designs for greenhouses for countries like Indonesia, Malaysia, Rwanda, Saudi-Arabia and The Netherlands.
	Time to innovate	3 years and longer
	Role of government	The Centre of Excellence could accommodate an Innovation & Demonstration Park with several types of greenhouses, small-scale working proto-types. With different levels of technology (e.g. from “updated solar greenhouses” to very high tech glasshouses), functions (e.g. water efficient, energy efficient) and costs. The government can stimulate researchers and designers (from China, The Netherlands and others as well) to design new greenhouses, and make it happen that the best designs will be build and demonstrated.

Greenhouse production: energy		
	Description	In Dezhou, it is recommended to use energy in winter for heating and probably additional lighting. Maybe also in summer, energy can be used for cooling greenhouses. Furthermore, CO2 of high purity is needed for high production levels.
	Expected impact	Higher production levels, but even more important: year round production of high quality crops.
	Key factors	The challenge is a smart and sustainable use of energy sources available. That means: (1) use production systems with low energy demand (energy saving), (2) use sustainable energy sources (solar, wind; perhaps hydroelectric, geothermal, biomass), (3) use energy as efficient as possible.
	Time to innovate	1-5 year
	Role of government	Provide energy infra structure, stimulate energy efficient production, assign (applied and fundamental) energy research

Greenhouse production: control of pests and diseases		
	Description	Pests and diseases are still widely controlled with chemical pesticides. For a higher level of food safety, “integrated pest management” (IPM) strategies should be implemented on a large scale.
	Expected impact	Higher level of food safety. Lower risks for workers applying the pesticides. Lower emission to the environment.
	Key factors	Strategies should be aimed on: (1) prevention: hygiene (no waste in and around greenhouses, remove sick plants, use hygiene protocols for employees and visitors, etc), keep insects out of the greenhouses, healthy climate control (low humidity) etc; (2) scout intensively on pests and diseases; (3) using advanced imaging detection and molecular diagnostic tools for disease and pest detection and diagnostics (4) use natural enemies, preferably locally sourced; (5) apply chemical pesticides as efficient as possible (time, dose, technology), chose specific pesticides that are harmless to natural enemies.
	Time to innovate	1-3 year
	Role of government	Collect waste. Assign research on IPM strategies. Organise knowledge dissemination: Demonstrate and train farmers.

Greenhouse production: water use		
	Description	Water of high quality in sufficient volumes are needed for high production and good quality. Water, specific of high quality, is scarce. Water use efficient systems should be developed and applied.
	Expected impact	Higher production, better quality, lower emission to the environment.
	Key factors	Start with the highest quality of water available. Normally, that is rain water, without the first flush, which should be collected in tanks or basins. Additional sources of water (ground water, surface water) should be purified. Implement high water use efficient cultivation systems, preferably substrates (Rockwool, coco peat etc.) with dripping irrigation and precise dosage of nutrients (computer controlled). Collect drain water, purify and reuse the water. Discharge as little as possible.
	Time to innovate	1-3 years
	Role of government	Facilitate water infrastructure. Prohibit water pollution.

Greenhouse production: robotics, camera vision & sensors, and ICT (e.g. big data)		
	Description	Support human sensing, decision making, and operations.
	Expected impact	Higher labour efficiency, higher quality & production, less failures
	Key factors	High tech materials, systems and high knowledge level. China is developing very fast in high tech industries. Application in horticulture is a big challenge, not only requiring technology knowledge & knowhow, but also knowledge of plant growth and development ('cross-over').
	Time to innovate	1-5 years
	Role of government	Facilitate connections between high tech material and system industry with horticulture. Innovate, demonstrate on Centre of Excellence.

Greenhouse production: plant models		
	Description	Plant models could be incorporated in Decision Support Systems (DSS). DSS can help growers to optimize their production. Growers will be able to monitor and steer crop growth and production, even on a distance. Another important application of plant models is the prediction of how many products will be harvested in which period. This is important information for marketing and planning of logistics.
	Expected impact	Better cultivation performance; data driven production, better aligned supply chains with less product losses.
	Key factors	Plant growth models are developed at several universities around the globe. Most of them are made for scientific purposes and have little practical value. Important is that models are validated on the specific conditions on a.o. climate and cultivation systems.
	Time to innovate	3 years
	Role of government	Support the development of models applicable for the Dezhou conditions. Make sure that data on harvest predictions can be used in supply chains (data architecture, governance)

Open field: pesticide application		
	Description	The easiest way to decrease pesticide applications and increase food safety is to improve the application. This means the right pesticide at the right time, with the right application technology and the right dose rate. Innovation tools can be earlier detection and diagnostic tools for the detection and identification of the problem at hand; schemes that give insight into the efficacy, effects to non-target organisms and resistance of pesticides; better targeted spay technology etc.. Demonstration and training will be included. Field trials to collect missing data can be considered. E-learning tools can be developed.
	Expected impact	The impact can be a considerable reduction of pesticides applied with a better effect on pest control and better conservation of natural enemies. This will lead to less cost for the farmer, higher yields and improved food safety.
	Key factors	This innovation is easy to implement but requires a good insight in the current knowledge of trainers. Demo activities are required to improve the learning process.
	Time to innovate	1 year

	Role of government	Set the conditions for pesticide application: admittance of pesticides, advised dose rates etc.

Open field: seed treatment with insecticides		
	Description	A technology that can easily decrease pesticide applications is the coating of vegetable seeds to protect the young plants against insect pests. This is especially effective against pests that damage crops at juvenile stages. An effective and low amount of a fungicide is coated on the seed and protects the seed against insect damage.
	Expected impact	The impact is that crop applications can be decreased, yield and food safety be improved.
	Key factors	In some cases, coated seeds might already be available. Where this is not the case, field tests are required to determine the right recipe including the coating. Some companies produce effective coating products.
	Time to innovate	1-5 year
	Role of government	Admission policy on pesticides.

Open field: Smart grading		
	Description	Smart grading technology allows grading of products like potato or onions to be graded fully automatically based on camera technology. This technology is available on the market.
	Expected impact	The impact is that grading will require less labour and will improve product quality.
	Key factors	A supplier need to be represented in China.
	Time to innovate	1 year
	Role of government	No specific role required.

Open field: precision farming		
	Description	This technology is based on linking geo locations of sensor readings to applications of seed, fertilizers and pesticides.
	Expected impact	The impact is that inputs for farming can be applied more precise and with more accuracy in relation to the need by soil and crop. This will give a better yield and quality and less pesticide application so improved food safety. Sensors are required to determine the status of soils and plants.
	Key factors	Part of the concept of precision farming is commercially available with companies. Yet, it can only be effective and economically feasible if large surfaces of crops occur and mechanisation is in place. The upscaling of production in the region can bring the application of precision farming more close.
	Time to innovate	>5 years
	Role of government	On the long run this technology can also lead to robotisation of the mechanization. This may require policies to be developed.

Open field: nutrient management		
	Description	The application of organic or chemical fertilisers need to be optimised based on the need of both the crop and the soil. Also, organic matter management needs to be considered as most organic manures also contain plant nutrients. An integrative approach on nutrient management will require training and demo's. Also, tools are available (such as the Soil Fertility Tool by WUR) that can be implemented and used by advisors and trainers. Easy to use

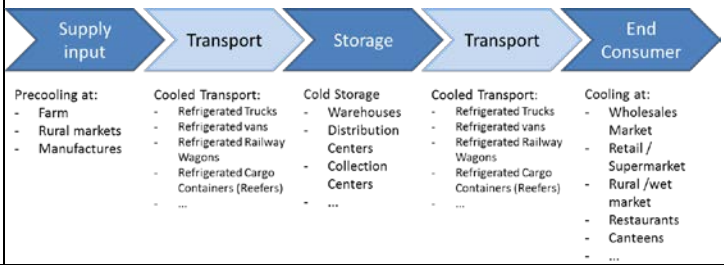
		fertilisation schemes can be developed for farmers. E-learning tools can be developed.
	Expected impact	The impact will be that farmers will use fewer nutrients (fertilisers). This will lead to improved product quality and decreased environmental pollution. On the long run, the knowledge, concepts and tools will uphold soil fertility and thus guarantee long term production potential of Dezhou soils.
	Key factors	This innovation is easy to implement but requires a good insight in the current knowledge of trainers. Demo activities are required to improve the learning process.
	Time to innovate	1 year
	Role of government	Set the conditions for fertiliser applications.

Open field: timing of vegetable production		
	Description	It is important for farmers to adapt their production planning to the anticipated market situation in order to profit from higher off-season prices and in order to mitigate their market risks. Measures are planning the planting and harvesting of crops, make harvest earlier or later by using mulch or variety choice or by using storage facilities.
	Expected impact	The impact will be that off-season production will increase and that overproduction is prevented to a certain extent.
	Key factors	The innovation will require applied testing by the CoE in Dezhou to determine to what level the above mentioned measures can be used and what their potential effect is.
	Time to innovate	1-5 years
	Role of government	No specific role required

Open field and greenhouse production: variety testing		
	Description	Varieties are a very important instrument to time production, to prevent diseases and pests and to guarantee the desired quality and taste. The performance of varieties is very much determined by the conditions under which the crops grow. Therefore, testing is required.
	Expected impact	The impact will be that the best varieties are used for the specific purposes of the Dezhou vegetable industry.
	Key factors	The availability of a large assortment of varieties.
	Time to innovate	1-5 years
	Role of government	No specific role required

Open field and protected cultivation: development of organic farming		
	Description	Organic farming is a production system that requires alternative ways to fertilize the crops and to suppress pests and diseases. This requires a systems approach. Soil health represents a pivotal function.
	Expected impact	Develop organic farming to increase production, decrease losses and increase quality.
	Key factors	This requires long term research on a farm level.
	Time to innovate	>5 years
	Role of government	No specific role required.

Open field: soil management quality		
	Description	Training on the integral approach to improve management of the soil. This training targets at the long term health of the soil and integrates soil structure, soil nutrient supply and disease prevention and control. It is advised to link this to demo's on best practices for soil quality. These demo's will require a long term character of the demo as best practices will show their value on the long run.
	Expected impact	The impact is that the insight into the different aspects of soil quality and their interrelationships will increase and that awareness is raised. The demo's will show best practices and have an educational and a research function at the same time.
	Key factors	Key factor is that training is connected to demos and that a long term approach is feasible.
	Time to innovate	On short notice more knowledge. For the demos a number of consecutive years is required and this fits well with the idea of a Centre of Expertise.
	Role of government	Incentives for good soil management.

Supply Chain: Closing the cold chain		
	Description	To improve the position of fresh products, many variables have to be managed where most important is the fact that the supply chain has to deliver the right products at the right time. Particularly important for fresh products is a good shelf life with minimum throughput time within a supply chain that takes care of the product quality by closing the cold chain. 
	Expected impact	When being able to close the supply chain for vegetables using the right temperature settings for the products in question the optimal shelf life and product quality can be reached.   *From current situation towards a possible new situation refrigerated equipment.* *Remark: product quality also depends on how the product is handled (see 'standardisation')*

		*Remark: closing the cold chain has also an impact on **food safety** related to spoilage of food and the fact that cooling needs warehouses, trucks, vans, etc. being closed so there is less change of cross contamination.*
	Key factors	Closing the cold chain needs chain cooperation / integration to prevent sub optimization where cooling in one part of the chain is eliminated by failing or wrong cooling in the other chain link. And it also calls for a mentality and awareness about the usefulness and necessity of a refrigerated chain. Furthermore to implement these innovation (huge) investments in hardware and knowledge is needed. However, the hardware (cooling equipment, refrigerated trucks, isolation materials, etc.) are standard and widely available. Also the needed insight in the optimal temperature settings for the different products are available through exchange with experts from, for example, the Wageningen University & Research.
	Time to innovate	For one dedicated chain 1 year
	Role of government	Set the conditions for investing in hardware (investment funds) and raising awareness in relation to **food safety**

Supply Chain: Standardisation		
	Description	Standard sizes for secondary packaging with the ground size 60x40 centimetres for optimal transport and handling. When using the ground size of 60x40 centimetres transport boxes, pallets, trucks, etc. will match and therefore stability during handling and transport will be much higher with less product damage resulting (leading to higher product quality) and higher efficiency.   *Examples of standardised transport packaging*
	Expected impact	In many ways standardization helps to upgrade the supply chain. An example is given by the logistic company LOSCAM (*fact finding mission province Weifang on 3-8 November 2016*), where discharging by pallets of a 12 MT truck can be reduced from 3-4 hours to 15-20 minutes . But in many cases food losses and bad product quality are due to mechanical damage and this can be avoided by stackable crates that moreover matches the size of the pallet and can be exposed directly in the store. Furthermore standardisation can also improve **food safety** due to the fact that products will know less cross contamination (of course, the absolute condition is that the crates, etc. are clean) when products no longer being transported in (open) trucks.

		  *From current situation towards a possible new situation using standardisation of handling equipment.*
	Key factors	See 'Closing the cold chain': Standardisation needs chain cooperation / integration to prevent sub optimization. And it also calls for a mentality and awareness about the usefulness and necessity standardise because it will improve chain efficiency, product quality and also food safety. Furthermore to implement these innovation (huge) investments in hardware and knowledge is needed. However, the hardware (cooling equipment, refrigerated trucks, isolation materials, etc.) are standard and widely available. Also the needed insight in how to treat and handle the different products, but this knowledge could be made available through exchange with experts from, for example, the Wageningen University & Research.
	Time to innovate	For a specific chain 6 months related to transport materials (boxes, pallets, crates). Also for loading and unloading equipment, a pooling system, washing facilities, etc. for returnable crates and pallets 1 to 2 year
	Role of government	Set the conditions for investing in hardware (investment funds) and raising awareness in relation to **food safety**

Supply Chain: Tracking and Tracing.		
	Description	With the continued threat and reality of foodborne illnesses and product recalls, food safety is a priority issue for the Chinese Government, consumers and food chain parties. Besides all the effort the entities in the food supply do to avoid contaminated food reaching consumers, many factors beyond the control of the food supply chain members can cause food safety violations. With a good tracking and tracing system in place it is possible to find out where these violations took place being able not only to recall the unsafe products, but also taking measures to improve the chain.
	Expected impact	The impact is twofold; first it will lead to better insight in the food chain regarding food safety being able to improve where necessary. And secondly in case of a recall this could be done based on the tracking and tracing information being able to pinpoint the place in the chain where these products are.
	Key factors	Essential for a good tracking and tracing system is compliance with (inter)national standards. Furthermore the infrastructure must be in place i.e. packing labels (barcodes), printers, scanners / readers at every point in the food chain, databases, etc.
	Time to innovate	> 5 years
	Role of government	Setting the standards and the law of tracking and tracing as part of the food safety programme

11 Conclusions

The main conclusion based on the visit of experts on greenhouse and open field vegetable production as well as logistics from Wageningen University & Research to Dezhou, the discussions with all the stakeholders and the analysis of the information, is that a Centre of Excellence (CoE) could be an important vehicle to catalyse the development of Dezhou's horticultural sector, considering the conditions set and provided supporting systems on marketing and information are in place.

The Centre should excel in bridging the gap between science and practice. This requires an organisational design that promotes co-operation between different experts and requires an embedment in a network with local stakeholders. The Centre works on implementation of new technologies in Dezhou's horticulture and will be using training, applied research and demonstrations as its main instruments. To this end, the Centre should be equipped with state-of-the-art facilities.

Involvement of companies and farmers who need to implement new technologies in their operations, is essential. Therefore, a financing structure should be built that matches their importance in the process and is aligned with the planning for especially the first five years. It is of eminent importance that knowledge is shared actively to build a strong fundament for the human capital in the horticultural sector.

At the same time, government incentives should contribute to the development while safeguarding food safety and supporting sustainability during the production phase.

A number of possible technologies or technology improvements have been listed. Yet, the challenge is to prioritise these technologies. This will require an interaction with all the stakeholders. To this end the different technologies should be scored on a variety of aspects such as cost, human capital requirement, expected impact on food safety and productivity, sustainability, the technology supply chain and co-operation need.

Wageningen University & Research can effectively contribute on different levels:

- Capacity building
- Advise on research, demonstrations and training methodology
- Support in applied research activities
- Advise on organisational design

To explore the potential of nature to improve the quality of life

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The mission of Wageningen University and Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 5,000 employees and 10,000 students, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.