

# GIES Case Study on Feng County Pear of the Ancient Yellow River Floodplain

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**Abstract:** The habitat of the ancient Yellow River floodplain areas of Feng county, Jiangsu province has nurtured soil that is conducive to fruit tree cultivation and created a unique environment for the development of the pear of Feng county. With a cultivation history spanning over two hundred years, the pear of Feng County has evolved into an renowned geographical brand. The main varieties include White Crisp Pear, Taking pear of Feng county as a case, this paper proposes a new model for sustainable development of pear in the ancient Yellow River floodplain areas of Feng county from five aspects: ecological and geographical environment, variety and quality, product development, socio-economic development and historical tradition. The case dataset consists of 6 parts: geographical location data of Feng county, Xuzhou city, the boundary data of county, township and village in the case area; topographical and geomorphological data of Feng county; climatic conditions data of Feng county in 2012–2022; surface water test results data of pear production area in Feng county; soil test results data of pear production area in Feng county; test results data of white crispy pear samples in Feng county. The data formats are .shp, .tif, .xls, .docx, etc. The data size is 11.8 MB (11.0 MB after compression).

**Keywords:** Feng county; the ancient Yellow River floodplain areas; pear; high quality geographical products ecological environment; case 15

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**CSTR:** <https://cstr.escience.org.cn/CSTR:20146.14.2023.02.02>

**Dataset Availability Statement:**

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: <https://doi.org/10.3974/geodb.2023.05.07.V1> or <https://cstr.escience.org.cn/CSTR:20146.11.2023.05.07.V1>.

## 1 Introduction

The Yellow River is honor as the mother river of the Chinese nation and has played an extremely important role in the historical, cultural and economic development of China<sup>[1]</sup>. The ancient Yellow River floodplain areas are special and complex geographical unit. Its formation is the result of the Yellow River's flooding, diversion, alluviation, siltation and wind erosion over the years<sup>[2, 3]</sup>. In recent years, under the guidance of the national strategy of "green development", the ecological protection of the ancient Yellow River floodplain areas has been improved, and it has become the origin of high-quality geographical products.

Most of Feng county, Xuzhou city, Jiangsu province, is covered by the ancient Yellow River floodplain areas, it is connected with Pei county in the east, Shan county in the west, Jinxiang in the north, and Xiao county in the south, and is in the center of Huaihai Economic Zone and the southeastern edge of North China Plain<sup>[4]</sup>. The climate is hot and rainy at the same time, with sufficient light and large temperature difference between day and night. The soil is a yellow tide soil developed from Yellow flood alluvial matrices, and the topsoil cover is mainly sandy, with deep, loose texture and strong permeability<sup>[5, 6]</sup>. The territory has a long history of culture, unique natural environment and abundant water resources. The forest coverage rate of fruit trees is 40%, which is the highest forest coverage rate in China.

Feng county's orchard industry has great advantages. With the full popularization of high-quality production technology, the quality of fruit products has obviously improved, and the level of industrialization and popularity has gradually increased. Among them, "Dashahé" brand white crisp pear is the first product of the county<sup>[7]</sup>. Pear because of its rich nutritional value and unique taste, loved by the majority of consumers. Through the study of the characteristics of pear and continuous innovation, the pear of Feng county has a high reputation and won many awards in the country and even internationally. This study relies on the system of "Global Change Scientific Research Data Publication & Repository"<sup>[8–11]</sup> to develop the case data set of ecological environmental protection and sustainable development in the ancient Yellow River floodplain areas of pear of Feng county<sup>[12, 13]</sup>, with the aim of supporting the ecological environmental protection and sustainable development in Feng county.

## 2 Metadata of the Dataset

The metadata information of the Dataset of geographical indications environment and sustainability (GIES) in Fengxian pear ancient Yellow River floodplain<sup>[14]</sup> is shown in Table 1.

## 3 Case Data Development

### 3.1 Geographical Data of the Study Area

Feng county is located in the northwest of Xuzhou city, Jiangsu province, connected with Pei county, Jiangsu province in the east, Shan county, Shandong province in the west, Jinxiang, Shandong province in the north, and Xiao county, Anhui province in the south, in the center of Huaihai Economic Zone and the southeastern edge of North China Plain<sup>[7]</sup>. The pear growing area of Feng county (Figure 1), which is located in the south of Feng county, including Dashahé town, Liangzhai town, Huashan town, Songlou town and Sunlou street.

The pear planting area in the case area is about 70,500 mu ( $\approx 4,700$  ha), and the planting area includes 62 administrative villages, 1 state-owned public welfare Feng county forestry field and 1 state-owned Feng county Dashahe forestry field. The population engaged in pear cultivation in the case area is about 63,000 households with a population of 180,000 people.

**Table 1** Metadata summary of the Dataset of geographical indications environment and sustainability (GIES) in Fengxian pear ancient Yellow River floodplain

Items	Description
Dataset full name	Dataset of geographical indications environment and sustainability (GIES) in Fengxian pear ancient Yellow River floodplain
Dataset short name	FengxianPearCase15
Authors	Zhang, Z. Q. 0000-0002-5577-2863, Jiangsu Normal University, zhangzq@jsnu.ac.cn Song, W. 0000-0003-4039-2339, Institute of Geographic Sciences and Natural Resources Research, China Academy of Sciences, songw@igsrr.ac.cn Yang, C. L., The People's Government of Feng County, 18252100236@163.com Gao, F. Y., Feng County Municipal Bureau of Agriculture and Rural Affairs, Research Institute of Pomology of Xuzhou, gfyfx@163.com Xu, X. L., Research Institute of Pomology of Xuzhou, xzfxxl@126.com Shi, W. J., HIX-9869-2022, Institute of Geographic Sciences and Natural Resources Research, China Academy of Sciences, shiwj@lreis.ac.cn Duan, Y. Q., Institute of Food Science and Technology, Chinese Academy of Agricultural Sciences, duanyuquan@caas.cn Li, D. H., Dashahe Town Agricultural and Rural Office, 1136838781@163.com Li, X. B., Xuzhou Ningxing Food Co., Ltd, mail126-126@126.com, Li, B. F., Feng County Baoling Green Fruit Professional Cooperative, 642941456@qq.com Hou, L. Y., Dashahe Town Runze Fruit and Vegetable Family Farm, Feng County, Fengxian_Houliyun@163.com Yu, H. GXJ-8116-2022, China University of Geosciences (Beijing), yuhhao@yeah.net Sheng, S. Q. HGT-0629-2022, Lanzhou Jiaotong University, Shengsq_up@163.com Li, S. C. GRT-9167-2022, Institute of Geographic Sciences and Natural Resources Research, China Academy of Sciences, lishuchang21@mailsucas.ac.cn Wei, X. HLP-5003-2023, Guilin University of Technology, 1020210012@glut.edu.cn
Geographical region	Feng county, Xuzhou city, Jiangsu province; geo-location: 106°33'55.8"E–107°39'42.1"E, 37°4'49.7"N–38°9'44.6"N
Year	2022
Data format	.xlsx, .shp, .tif, .jpg, .docx
Data size	11.8 MB (11.0 MB after compression)
Data files	(1) geographical location data of Feng county, Xuzhou city, case area county, township and village boundary data (2) topographical and geomorphological data of Feng county (3) climatic conditions data of Feng county in 2012–2022 (4) surface water test results data of pear production area of Feng county (5) soil test results data of pear production area of Feng county (6) test results data of white crispy pear samples of Feng county
Foundation	National Natural Science Foundation of China (42071233)
Data publisher	Global Change Research Data Publishing & Repository, <a href="http://www.geodoi.ac.cn">http://www.geodoi.ac.cn</a>
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	<b>Data</b> from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the <i>Digital Journal of Global Change Data Repository</i> ), and publications (in the <i>Journal of Global Change Data &amp; Discovery</i> ). <b>Data</b> sharing policy includes: (1) <b>Data</b> are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use <b>Data</b> subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute <b>Data</b> subject to written permission from the GCdataPR Editorial Office and the issuance of a <b>Data</b> redistribution license; and (4) If <b>Data</b> are used to compile new datasets, the 'ten per cent principal' should be followed such that <b>Data</b> records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset <sup>[7]</sup>
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

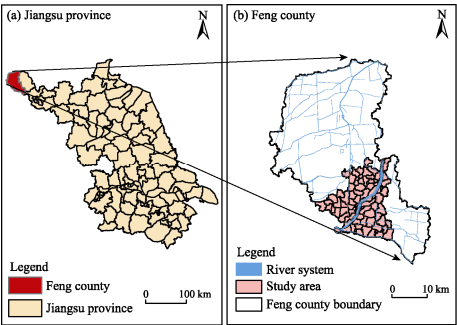
3.2 Ecological Environmental Data

3.2.1 Topography

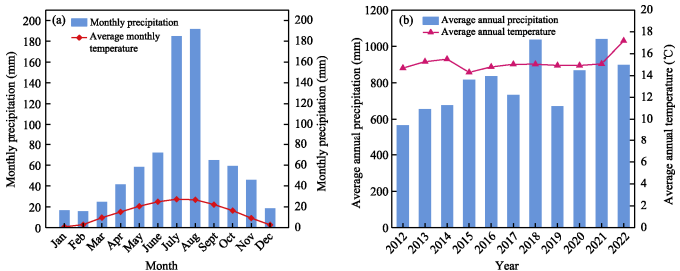
Feng county has a flat topography and is a yellow pan alluvial plain with 46.6% sandy terrain and very small denuded remnant hills<sup>[14]</sup>. The topography of Feng county is high in the southwest and low in the northeast (Figure 1). The main river in the county is in the direction of north to south<sup>[15]</sup>, and the tributaries are mostly west-east trending, forming a net-like county landform type, except for a very small remnant hill slightly south of the east, most of the land is governed by the influence of the original landform topography and the law of rapid sand diffuse siltation deposition due to the overflow and diffuse flow of yellow water.

3.2.2 Climatic Conditions

Feng county is a warm temperate semi-humid monsoon climate zone with four distinct seasons and abundant light, and it is one of the lowest temperature and lowest precipitation counties in Jiangsu<sup>[16]</sup>. The average annual temperature in Feng county is about 15 °C, the average annual precipitation is about 630.4 mm, rain and heat are in the same season (Figure 2). The frost-free period is about 210 days. From 2012 to 2022, there is no significant change in the average annual temperature in Feng county, and the annual precipitation shows an increasing trend (Figure 2).



**Figure 1** Location of Feng county, Shuzhou city, Jiangsu province

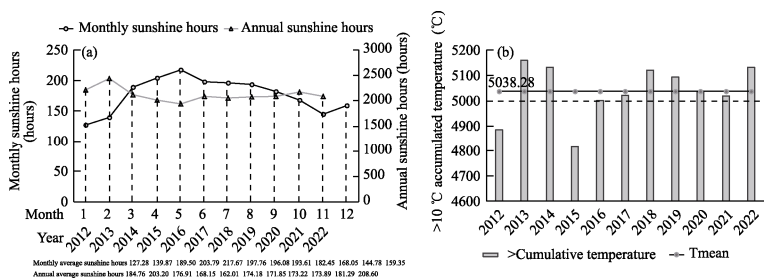


**Figure 2** Changes in temperature and precipitation in Feng county from 2012 to 2022: (a) monthly average temperature and monthly average precipitation; (b) annual average temperature and annual average precipitation

From 2012 to 2022, Feng county has long monthly sunshine hours, the average monthly sunshine hours is about 177 hours, and the strongest sunshine months are concentrated in April–June (Figure 3). The average annual accumulation temperature  $\geq 10^{\circ}\text{C}$  is 5,038.28 °C. Only in 2012 and 2015, the temperature was not lower than 5,000 °C, and the rest of the years are greater than 5,000 °C. The light condition is good. It is suitable for the cultivation of pear trees.

3.2.3 Water Resources

The water source of Feng county pear plantation is mainly the Dasha River. In this study, the Dasha River was sampled and tested for water quality, and 1 sampling point was laid out (Figure 4). Before sampling, first rinse the water sample container with water samples 2-3 times, then make the barrel against the direction of the water flow into the water filled with water barrel, quickly put forward the water surface, without stirring the sediment at the bottom of the water, should avoid the water surface floating objects into the sampling barrel.



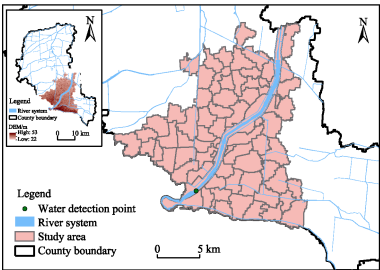
**Figure 3** Changes in sunshine hours and cumulative temperature activity in the study area of Feng county from 2012 to 2022

Referring to the basic control items specified in the “Standard for Irrigation Water Quality” (GB 5084—2021)<sup>[17]</sup>, the detection items were PH, water temperature, suspended solids, anionic surfactants, five-day biochemical oxygen demand, chemical oxygen demand, chloride (as  $\text{Cl}^-$ ), sulfide (as  $\text{S}^{2-}$ ), total salt, fecal coliform count, total mercury, total lead, total arsenic, total cadmium, chromium (hexavalent), total 15 items. The test results showed that the indicators of irrigation water quality in the case area did not exceed the standard (Table 2), which met the requirements of the limit value for dryland crops stipulated in the standard for irrigation water quality (GB 5084—2021)<sup>[17]</sup> and met the requirements of pear production on the source water quality.

**3.2.4 Soil Conditions**

**(1) Surface soil conditions**

Due to the case area near the former Yellow River outflow, the water flow is rapid, the texture is mostly loose sand, tight sand or sandy loam, the development of the formation of flying foam sandy soil and sandy soil, the formation of the Yellow River ancient road beach. Soil nutrient content is low compared to other town soil nutrients. In this study, sampling and testing were conducted on the surface soil of the pear orchard planting area, and four sampling points were mainly set up in Dashahe town and Songlou town (Figure 5), including the hundred-year pear orchard located in Li Building village of Songlou town. According to the technical specification for soil environmental monitoring (HJ/T 166—2004)<sup>[18]</sup>: 0–60 cm soil was collected for planting fruit and forestry crops; in order to ensure the representativeness of the samples, the five-point sampling method was used; each soil sample was collected about 1 kg and put into a sample bag, while the sample label and sampling record were filled out by one person to mark the sampling time, location, number, sampling depth, and the sampling period, location, number, sampling depth, latitude and longitude, and other information.

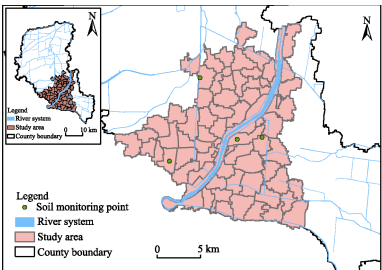


**Figure 4** Map of water sample testing points in the case area

**Table 2** Statistics of irrigation water quality

Pollutant Items	Limit value (≤)	Test results
pH	5.5–8.5	8.1
Water temperature (°C)	35	24.9
Suspended solids (mg/L)	100	<5
Five-day biochemical oxygen demand (BOD <sub>5</sub> ) (mg/L)	100	0.8
Chemical oxygen demand (COD <sub>Cr</sub> ) (mg/L)	200	6
Anionic surfactants (mg/L)	8	<0.05
Chloride (as $\text{Cl}^-$ ) (mg/L)	350	103
Sulfide (as $\text{S}^{2-}$ ) (mg/L)	1	<0.01
Total salt (mg/L)	1,000	674
Total lead (mg/L)	0.2	0.000,09
Chromium (hexavalent) (mg/L)	0.1	<0.004
Total mercury (Mg/L)	0.001	<0.000,04
Total arsenic (Mg/L)	0.1	0.000,6
Total cadmium (mg/L)	0.01	<0.000,05
Fecal coliform count (MPN/L)	40,000	<20

Based on the requirements for the origin environment in the Environmental conditions of origin for pollution-free food forest and fruit products (NY 5013—2006)<sup>[19]</sup>, and combined with the Technical specification for soil environmental monitoring (HJ/T 166—2004)<sup>[18]</sup> and the Soil environmental quality risk control standard for soil contamination of agricultural land (GB 15618—2018)<sup>[20]</sup>, this study determined a total of 16 basic items for soil testing, soil fertility indicators and soil environmental indicators. Among them, two basic items include soil pH and cation exchange capacity; four soil fertility indicators include organic matter, total nitrogen, available phosphorus and available potassium; and 10 soil environmental indicators include zinc, arsenic, cadmium, nickel, lead, mercury, chromium, copper, hexachlorocyclohexane and DDT. The soil pH in the case area was 8.09–8.23, and the test results of soil environmental indicators were referred to the soil environmental quality risk control standard for soil contamination of agricultural land (GB 15618—2018)<sup>[20]</sup>, and all the test indicators were lower than the soil contamination risk screening value (pH>7.5) (Table 3). The soil environmental quality of the case area is well and meets the requirements of pear production on the origin soil environment.



**Figure 5** Map of soil sampling sites in the case area

**Table 3** Statistics of soil environmental index

Pollutant items	Risk screening value (mg/kg) (pH>7.5) <sup>[20]</sup>	Test results of soil samples (mg/kg)			
		L-1	L-2	L-3	L-4
Cd	0.6	0.12	0.15	0.089	0.12
Hg	3.4	0.015,3	0.016	0.015	0.015,7
As	25	8.57	10.7	10.1	12.3
Pb	170	18	15	15	14
Cr	250	47	47	38	44
Cu	200	15	33	63	89
Ni	190	21	18	11	16
Zn	300	49	51	37	50
Hexachlorocyclohexane	0.1	<0.000,06	<0.000,06	<0.000,06	<0.000,06
DDT	0.1	<0.000,09	0.047,9	0.009,09	0.000,79

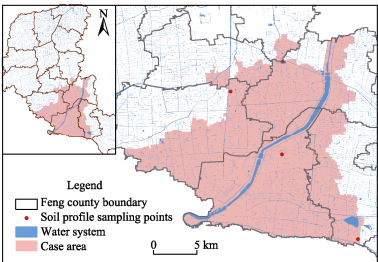
Soil fertility is a measure of the ability of the soil to provide various nutrients required for crop growth, and soil N, P, K and organic matter are both important indicators of soil fertility. The results of soil fertility indicators (Table 4) showed that the soil organic matter and total nitrogen content in the 0–60 cm soil layer in the case area were low.

**Table 4** Statistics of soil fertility index

Sample site	Organic matter (g/kg)	Total nitrogen (g/kg)	Available phosphorous (mg/kg)	Available potassium (mg/kg)
L-1	7.82	0.42	10.7	108
L-2	6.51	0.43	27.8	83
L-3	4.18	0.28	17.4	52
L-4	7.62	0.47	41.8	84

## (2) Deep soil conditions

Soil profiles record the various soil-forming effects that may have occurred and are still occurring under the influence of soil-forming factors. In order to investigate the deep soil conditions in the Ancient Yellow River floodplain areas, one soil profile sampling site was set up in each of the four major townships in the case area (Huashan town, Songlou town, Dashahe town and Liangzhai town) in this study (Figure 6). The specifications of the soil profile were 1.2 m in length, 1.0 m in width, and 1.2 m in depth. The soil profile was excavated with the observation surface facing the sun, and the topsoil and subsoil were placed on both sides. The profiles were repaired and smoothed, some rough surfaces were picked out to avoid obvious knife marks, and profile photos, landscape photos and feature photos were recorded as needed (Figure 7). Soil samples were collected in layers for each profile, with each layer spaced 20 cm apart, for a total of 6 layers of soil samples, with 1 kg of samples collected from each layer, placed in sample bags, and recorded by a designated person. Through the stratified collection of soil samples, the fertility conditions of the deep soil in the pear planting area were tested, and the test items included pH, cation exchange, organic matter, total nitrogen, available phosphorus and available potassium.



**Figure 6** Map of soil sample sites in the case area



**Figure 7** Soil profile of sampling sites in the case area

The results of the soil profile samples showed (Table 5) that the variation of soil pH in the case area ranged from 8.18 to 8.63, with a mean value of 8.40, which is typical of alkaline soil. The difference in soil pH between layers at different points was small; the mean value of soil pH in the 0–20 cm soil layer was 8.23, which was higher in the deeper layers compared to the surface soil, and the mean value of soil pH in all layers between 20–120 cm was greater than 8.40. The soil cation exchange capacity (CEC) is important for evaluating the fertility holding capacity of the soil, and the magnitude of its value represents the amount of nutrients that the soil can hold. The variation of soil CEC in the case area ranged from 3.30–13.70 cmol(+)/kg. Compared to the 20–60 cm soil layer, the soil CEC was higher in the 60–120 cm soil layer, especially in the 80–100 cm soil layer, where the soil CEC reached a maximum of 13.70 cmol(+)/kg and the mean value was 8.87 cmol(+)/kg, indicating that the case area The deep soil has a strong fertilizer retention capacity, which is related to the soil formation process in the case area, which is also conducive to the nutrient extraction by the deep root system of pear trees.

The results of the soil fertility index tests in different soil layers are shown in Figure 8. From the different points, the highest organic matter content was found in the 0–20 cm surface soil, reaching 10.10–19.70 g/kg, with an average value of 15.58 g/kg (Figure 8a) and

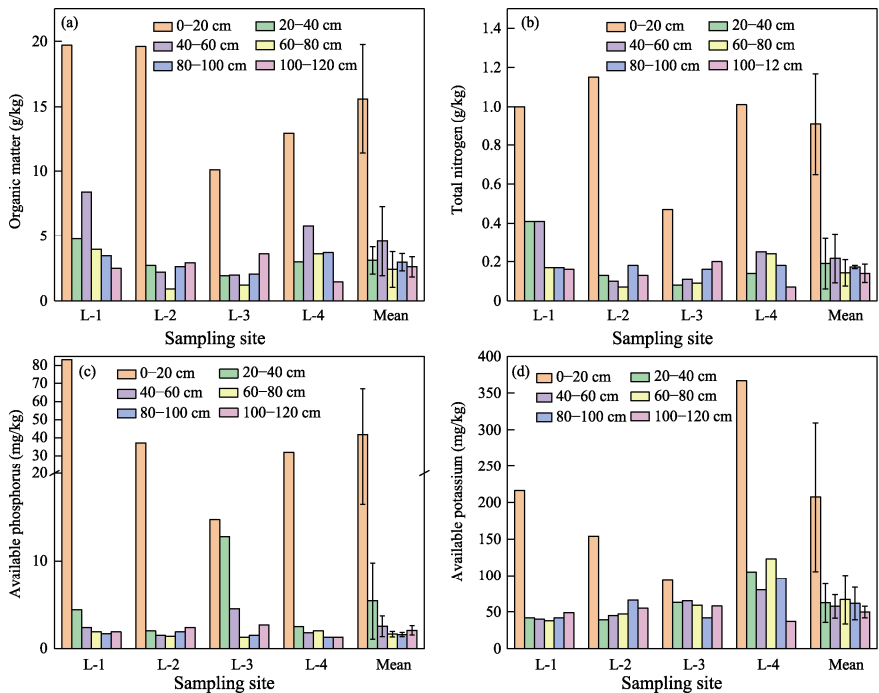


medium nutrient content. There are two trends in soil organic matter content with increasing

**Table 5** Statistics of soil profile sample ph and cation exchange capacity (CEC) test results

Soil Depth (cm)	pH					CEC / (cmol(+)/kg)				
	L1	L2	L3	L4	Mean	L1	L2	L3	L4	Mean
0–20	8.22	8.32	8.18	8.21	8.23±0.05	9.52	10.00	4.60	9.33	8.36±2.19
20–40	8.20	8.40	8.55	8.43	8.40±0.13	7.17	3.76	3.30	5.01	4.81±1.50
40–60	8.43	8.36	8.68	8.49	8.49±0.12	6.41	5.72	3.56	6.19	5.47±1.13
60–80	8.36	8.37	8.60	8.34	8.42±0.11	6.75	5.60	3.59	9.69	6.41±2.21
80–100	8.39	8.37	8.49	8.36	8.40±0.05	6.57	10.30	4.91	13.70	8.87±3.40
100–120	8.33	8.41	8.45	8.57	8.44±0.09	7.01	7.29	7.65	4.40	6.59±1.28

soil depth: (1) decreasing and then increasing (points L2 and L3), with the lowest soil organic matter content of 0.91–3.95 g/kg in the 60–80 cm soil layer; (2) decreasing and then increasing and then decreasing (points L1 and L4), with the organic matter content of 20–40 cm soil layer and 60–120 cm soil layer. The soil organic matter content of soil in the 20–40 cm and 60–120 cm soil layers was lower than that in the 40–60 cm soil layer. The trend of soil total nitrogen content was basically the same as that of soil organic matter (Figure 8b). Among the different soil layers, the 0–20 cm surface soil had the highest available phosphorus content with a mean value of 41.78 mg/kg (Figure 8c), which was rich in nutrients; followed by the 20–40 cm soil layer; the 40–120 cm deep soil showed a trend of decreasing and then increasing effective phosphorus content, but the change was small. In addition, the available potassium content in the 0–20 cm surface soil was the highest, with a mean value of 207.5 mg/kg (Figure 8d), which was rich in nutrients; the available potassium content in the 20–120 cm soil layer showed a small variation and no obvious change pattern, with medium nutrient content.

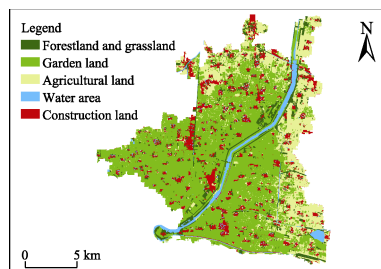


**Figure 8** Soil organic matter (a), total nitrogen (b), available phosphorus (c) and available potassium (d) in different soil layers



### 3.2.5 Land Use Type

Feng county has fertile land and abundant production<sup>[21]</sup>, and enjoys the reputation of “Feng ripening can reach three states”. The land use types in the main pear production area of Feng county include garden land, agricultural land, construction land, water area and ecological land (Figure 9). Among them, the largest area of garden land is the main land use type, followed by agricultural land and construction land; agricultural land is mainly distributed in the north and east of the pear production area, and construction land is mainly rural settlements, which are evenly distributed in all directions of the pear production area. Finally, the pear production area also has a certain amount of forestland and grassland, which forms a diverse ecosystem and provides a good ecological environment for pear productions.



**Figure 9** Map of land use in the case area

## 3.3 Product Characteristics Data

### 3.3.1 Pear Varieties of the Ancient Yellow River Floodplain Areas of Feng County

As the main fruit of the ancient yellow river floodplain areas of Feng county, pear occupies a key position in the fruit industry of Feng county<sup>[7]</sup>. Feng county is located in the white pear area of northern China, with good light conditions, sufficient heat and moderate rainfall, large temperature difference between day and night, and the climate is between dry and cold in the north and wet in the south, which is suitable for the growth of pear trees.

Feng county is in the dominant pear production area, white pear is the main pear varieties. According to the “Feng County Brief History”<sup>[22]</sup>, it is named because the fruit is juicy and crispy, and has hundreds of years of cultivation history in Feng county, which is a famous and excellent variety. Because the market has a large demand for early and medium-ripening varieties, adjusting the variety structure of pear is the key. In the mid-90 s, Feng county started to introduce the Japanese and Korean pear varieties represented by Fengshui pear and Huangjin pear; the early 21st century introduced the Huangguan, Yuanhuang pear and other pear varieties were introduced. Since 2013, Feng county further optimized the variety structure, accelerated the introduction of early maturing type, multi-resistant pear varieties, promoted Sucui 1, Qiuyue pear and other new pear varieties. At present, Feng county has realized the reasonable collocation of early, medium and late varieties, adapted to the trend of fruit development, and improved the fruit market competitiveness and economic benefits.

### 3.3.2 Pear Variety Characteristics of Feng County

#### (1) White crispy pear

The fruit of white crisp pear is almost cylindrical, the top flat truncated slightly wide; the skin is light golden yellow, slightly light brown, the fruit point is small and dense; the heart is small, the flesh is white as jade, crisp and juicy, the taste is strong and sweet<sup>[7]</sup>, the soluble solids can reach more than 11%. In addition to the crisp and sweet flesh, white crisp pear also has the characteristic of strong storage and transportation ability, which can be stored at room temperature until March of the following year after harvesting in September of the year. In addition, thanks to the suitable growth environment and good management mode, the longer the white crisp pear tree out of the pear fruit quality is better. the fruit is large with thin skin, fine flesh. The pear is juicy and sweet, crisp and crumbly with less stone cells.

#### (2) Huangguan pear

Huangguan pear is a medium to early maturing pear variety, which has become one of the main pear varieties<sup>[23]</sup>. Huangguan pear fruit is spherical and large, beautiful appearance, the skin is golden yellow when ripe. The fruit surface is smooth, and the fruit point is small. The flesh is white and fine, and the heart is small. The fragrance is strong. Fruit storage re-

sistance, natural conditions can be stored for 20 days, refrigerated conditions can be stored until April of the following year<sup>[24]</sup>.

### (3) Yuanhuang pear

Yuanhuang pear is an early-ripening pear variety introduced from abroad, which has strong fruiting ability and good productivity<sup>[25]</sup>. Yuanhuang pear fruit has a flat round appearance, and the skin is golden yellow to reddish brown when ripe; the flesh is snow-white, with delicate taste and no dregs, juicy, soluble solids up to 15% or more, sweet taste and almost no acidity<sup>[26]</sup>.

### (4) Sucui 1 pear

Sucui 1 pear is a new variety of early maturing sand pear system, with early maturity and excellent quality<sup>[27]</sup>. The fruit of Sucui 1 pear is obovoid, and the skin is light green when ripe. The fruit surface is smooth, and the fruit point is medium to large. The flesh is white and fine, and the heart is small. The soluble solids is about 12%<sup>[28]</sup>.

### (5) Cuiguan pear

Cuiguan pear is an early maturing sand pear family variety, and it is also the first cultivar in the south of the Yangtze River basin in China<sup>[29]</sup>. The fruit of Cuiguan pear is nearly round. The fruit surface is clean, and the skin is yellow-green when mature. The flesh is white and tender, and the flavor is with honey fragrance. The taste is strongly sweet, and the soluble solid content is 12%–14%<sup>[30]</sup>.

### (6) Qiuyue pear

Qiuyue pear is a late maturing variety of sand pear system, with characteristics of abundant yield, good quality, cold and drought resistance<sup>[31]</sup>. The fruit of Qiuyue pear is flat and round, and the fruit shape is square. The skin is yellowish brown, thin, waxy and shiny. The flesh is creamy white, fine and brittle, and the heart is small. The taste is sweet and juicy. The soluble solids content is 13.5%<sup>[32]</sup>.

## 3.3.3 Test Analysis of Pear Quality of Feng County

White crisp pear is the main variety of Feng county. For Feng county white crisp pear, this study entrusted Pony Testing International Group to test and analyze its quality. According to “Fresh pear” (GB/T 10650—2008)<sup>[33]</sup>, “Food safety national standard for contaminants in food” (GB 2762—2022)<sup>[34]</sup>, “Food safety national standard for maximum residue of pesticides in food” (GB 2763—2021)<sup>[35]</sup> and the regulations in the Technical regulations for the production of white pears (DB32/T 527—2009)<sup>[36]</sup>, the quality indicators selected in this study include sensory requirements, physical and chemical indicators, safety and health indicators and nutritional value. Among them, the sensory requirements include fruit shape, color and fruit surface defects and other 6 test items. Physicochemical indicators, i.e. intrinsic quality, including 3 tests of fruit hardness, soluble solids and titratable acid content. Safety and health indicators include cadmium, lead and arsenic content and other 6 contaminants content and trichlorfon, dichlorvos and glyphosate and other 47 pesticide residues. Nutritional value includes 36 tests such as vitamin C, vitamin E and amino acid content.

### (1) Sensory qualities

In the sensory aspect, Feng county white crisp pear has the variety characteristics, flavor and color of crisp pear, the fruit is intact and the fruit shape is square, the fruit pedicel is complete, the fruit surface is free of defects, and has good appearance quality, which basically meets to the quality grade requirement of superior product according to Fresh pear (GB/T 10650—2008)<sup>[33]</sup> (Table 6).

### (2) Flavor quality

Fruit hardness is one of the important indicators to judge the maturity and quality of pear

fruit, and also directly related to storage and transportation. The fruit hardness of Feng county white crisp pear is 4.6 kg/cm<sup>2</sup>, which is in accordance with the reference value of physicochemical index of crisp pear varieties specified in Fresh pear (GB/T 10650—2008)<sup>[33]</sup> (Table 7), which also makes it have better storage resistance.

**Table 6** List of Feng county white crisp pear sensory index

Project indicators	Feng county white crisp pear sensory quality
Basic requirements	Sphere-like, with pear flavor, ripeness suitable for marketing and storage requirements, good fruit integrity, fresh and clean, no odor, no foreign moisture
Fruit shape	Fruit shape decent, sphere-like
Color	Yellow
Fruit stalks	Fruiting pedicels intact
Size neatness	Fruit cross diameter difference <25 mm
Fruit surface defects	No puncture wounds, broken skin scratches, bruises, abrasions, water rust, drug spots, sun-burn, hail injuries, insect injuries, diseases, insect fruits

**Table 7** List of Feng county white crisp pear physical and chemical index

Project indicators	Unit	Test results	Pastry pear reference value	Ya pear reference value	Long handle pear reference value
Fruit hardness	kg/cm <sup>2</sup>	4.6	4.0–5.5	4.0–5.5	7.0–9.0
Soluble solids	%	11.7	≥11.0	≥10.0	≥10.5
Titrateable acid	%	0.19	—	—	—

Note: The reference values of fruit hardness and soluble solids of pear varieties refer to “Fresh pear” (GB/T 10650—2008)<sup>[33]</sup>.

Soluble solids and sugar-acid ratio are important indicators to evaluate the intrinsic quality and flavor of pear fruit<sup>[37]</sup>. The sugar-acid ratio is the ratio of soluble solids to titrateable acid and is used to evaluate the flavor, sweetness and acidity of pear fruit<sup>[38]</sup>. When the acid content is very low (<0.4%), the proportion of high-quality fruit is greater<sup>[39, 40]</sup>. Compared with varieties such as Ya pear and long handle pear, the soluble solids content of Feng county white crisp pear was higher (11.7%) and its titrateable acid content was lower (0.19%), with a sugar-acid ratio of 61.6, resulting in a strong sweet and crisp taste.

(3) Health and safety quality

In this study, the contents of 6 contaminants and 47 pesticide residues were detected and analyzed in white crisp pear fruits (Table 8). Among them, two indicators, monofor-mamidine pesticide and carbendazim, were detected, but their contents were much lower than the maximum residues specified in the national standards, and the test results of other indicators were all undetected. This shows that the test indexes of Feng county white crisp pear are qualified, and its production process meets the health and safety standards, and the health and safety quality can be effectively guaranteed.

**Table 8** List of Feng county white crisp pear safety and health indicators

Project indicators	Applications	Test results	Limits / Maximum residue limits <sup>[35]</sup>
Monoformamidine pesticide	Insecticide	0.12 mg/kg	0.5 mg/kg
Carbendazim	Fungicides	0.038 mg/kg	3 mg/kg
Other indicators	—	Undetected	—

(4) Nutritional quality

The nutritional quality of pear fruit is more related to the variety<sup>[41]</sup>. Feng county pear is rich in nutrients, and the fruit is rich in polysaccharides, vitamins, organic acids, proteins

and dietary fiber and other nutrients. In view of the fact that Feng county is located in the ancient panhandle and belongs to the main white pear production area in North China, we took white crisp pear as an example and conducted the analysis of the nutritional quality components of Feng county pear to explore the unique pear nutritional quality substances formed by the origin of Feng county white pear.

Moisture is an extremely important indicator of fresh fruits, and many nutrients can be absorbed by the human body only after dissolving in water. The water content of pear fruit is generally in 80%–85%<sup>[42]</sup>, and white crisp pear reached 87.9%, which also reflects its juicy characteristics.

Sugar substances play an important role in the quality, nutritional value and storage resistance of pear fruit, and the sugar in pear fruit is mainly fructose and glucose. Compared with the Ya pear and Xuehua pear of white pear system, the glucose content in the fruit of Feng county white crisp pear is moderate, between the two varieties, but its fructose content is high, reaching 4.8 g/100 g (Table 9). The sweetness of fructose and glucose were different, and the sweetness of fructose was higher than that of glucose. In addition, the sweetness of the fruit was related to substances such as organic acids and tannins. Organic acids give the fruit a unique flavor, and pear fruit is a typical malic acid type fruit<sup>[43]</sup>. The malic acid content in white crisp pear fruit is between that of Xuehua pear and Ya pear, reaching 6.2 mg/g (Table 9). Tannins are polyphenolic compounds with wide application value in antioxidant, antibacterial and anticancer<sup>[44]</sup>. The tannin content in the fruit of Feng county white pear was 579 mg/kg (Table 9), which is roughly comparable to the tannin content of wild prickly pear<sup>[45]</sup> and has high nutritional value. The proper ratio of sugars, organic acids and tannin content achieved the characteristics of Feng county white crisp pear with strong sweetness and beauty.

More than half of the human diet is derived from fruits and vegetables, and vitamins play an active role in maintaining human health. Among them, vitamin C content has an important influence on the nutritional value of fruits. Compared with Ya pear and Xuehua pear, Feng county white crisp pear has higher vitamin C content, which can reach 3.28 mg/100 g (Table 9).

**Table 9** List of Feng county white crisp pear sugar, vitamin C and malic acid index

Project indicators	Unit	Feng county White crisp pear	Ya pear <sup>[46,47]</sup>	Xuehua pear <sup>[46,48]</sup>
Glucose	g/100g	2.3	2.46–2.78	0.95
Fructose	g/100g	4.8	4.11–4.38	3.94
Malic acid	mg/g	6.2	1.05	7.29
Vitamin C	mg/100g	3.28	2.32	2.33–3.49
Crude fiber	g/100g	1.0	4.63	5.94

Cellulose, hemicellulose and lignin are collectively known as “crude fiber”, and too much crude fiber in the fruit will result in a coarse, hard and crumbly flavor<sup>[42]</sup>. The stone cell in the pear fruit is made of cellulose and hemicellulose of the fine thick-walled cells, and therefore in the consumption will have a sand texture when consumed<sup>[46]</sup>. Compared with Ya pear and Xuehua pear, the crude fiber content in the fruit of Feng county white crisp pear is much smaller than the other two varieties, only 1.0 g/100 g. This also reflects the delicate flesh, crisp and crumbly taste characteristics of Feng county white crisp pear, which has good inherent quality.

Amino acids are basic substances for life metabolism and important components of proteins in living organisms, and their rich variety is an important indicator for evaluating the nutritional quality of fruits<sup>[49]</sup>. A total of 16 amino acids were detected in this dataset, and the total amino acid content of Feng county white pear was 190 mg/ 100 g, among which, seven essential amino acids such as alanine, threonine and leucine were 40 mg/100 g (Figure

10). According to the results of previous studies<sup>[46, 50]</sup>, the total amino acid and essential amino acid contents of Feng county white crisp pear were higher than those of both Huangguan pear and Xuehua pear varieties, and the protein content was in between the two varieties, which was 420 mg/100 g, and the difference was small. Through the above nutritional quality indexes, it can be seen that the fructose, malic acid, tannin, vitamin C, crude fiber and amino acid contents of Feng county white crisp pear are higher than those of pear varieties in related domestic areas, forming the unique taste of Feng county white crisp pear.

## 4 Management

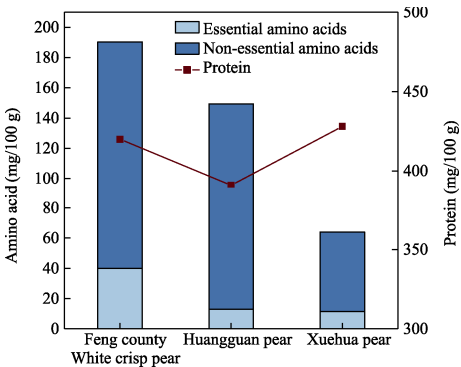
As of 2022, Feng county pear planting area of 70,500 mu, production of 142,000 tons, annual output value of 343,771,600 Yuan. In recent years, Feng county government to help revitalize the pear industry, the formation of government-enterprise-cooperative (family farm) tripartite synergy, extend the pear industry chain to strengthen the pear brand construction, the use of modern technology to develop intelligent pear industry, so as to achieve sustainable development of Feng county pear industry.

### 4.1 The Role of Government

Government support is the strongest guarantee for the sustainable development of the pear industry in Feng county. Since 2019, Xuzhou city and Feng county finance departments have listed 22 million Yuan and 80 million Yuan each year to establish special funds for infrastructure and environment for fruit industry development to support the development of pear and other fruit industries<sup>[51]</sup>. Feng county government has jointly established the Feng County Fruit Industry Research Institute with Nanjing Agricultural University and Jiangsu Academy of Agricultural Sciences. At present, Feng county pear has been awarded the national geographical indication trademark product, and a series of standards have been formulated to meet the green food A-grade standard, which is the valuable intellectual property of the people of Feng county and the result of the long-term efforts of the Feng county government, people and all circles. The next step is the tripartite linkage of government-market-farmer to form a synergy, with the government taking the lead in linking enterprises to drive farmers, linking farmers to promote agriculture and drive the development of grassroots industries. Under the promotion of the government, around the fruit industry resources in Feng county, agricultural investment has been increasing, and a number of leading fruit processing enterprises have been established, such as Andeli Fruit and Vegetable Juice Co. Ltd., Ningxing Food Co., Ltd., Lin's Shop<sup>[52]</sup>. The operation mode of "government guidance, enterprise leadership, and farmer participation" and the sustainable development mode of "market-led, who invests, who benefits" have been formed. And Jiangsu Dashaher Modern Agricultural Industry Group was established. It has adopted the operation mode of "government guidance, enterprise leadership, farmer participation" and the sustainable development mode of "market-led, who invests, who benefits".

### 4.2 Optimize the Pear Value Chain

Industrialization is the inevitable way to build a



**Figure 10** Amino acid and protein content and comparison of Feng county white crisp pear

Note: The data of indicators related to Huangguan pear and Xuehua pear were obtained from references [46] and [50].

modern pear industry chain and pear brand construction. At present, Feng county pear garden scale, regionalization significantly enhanced. To the Yellow River and the old road modern fruit production demonstration area as the carrier, focus on building fruit “one district, three gardens, one hospital, ten bases” construction. Feng county has built 10,000 mu ( $\approx 666.67$  ha) of national export fruit demonstration park, the Yellow River and the road 10,000 mu ( $\approx 666.67$  ha) of ecological fruit demonstration park and Dasha River Group fruit logistics park<sup>[52]</sup>, set up the Feng county fruit industry research institute; construction of Dachengzhuang in Huashan town, Songlou village in Songlou town, Lidalou Centennial Pear Garden in Songlou town, Shengshi Pear Garden in Dashahe town, Honglou in Liangzhai town and other 10 high-quality pear garden, guide new business units to carry out green food, organic food certification, Register trademarks and build brands. Continuously improve the marketing system, based on the basis of stable brokers, fruit markets and other traditional sales channels, build e-commerce, built the Dashahe Group e-commerce logistics park, Dashahe town e-commerce industrial park, Songlou town e-commerce industrial park, etc.<sup>[53]</sup>, build supporting cold storage, carry out generation storage services, encourage individual households to carry out live with goods, incubated the “Fengxian big mosquito and small mosquitoes” Wang Wenwen sisters, “Linfeng fruit industry” Li Jie, “three old mothers” Zhang Xuan and a number of live with the main body, Feng county pear sales system gradually improved, sales market continues to expand. Relying on the production base, guide the processing enterprises and base docking, cooperation, establish “enterprise + base + farmers” the joint farm with farmers mechanism, the formation of the community of interests.

### 4.3 Digital Transition

The sustainable development of the pear industry cannot be separated from the promotion of science and technology. Feng county pear industry always takes science and technology as support, and constantly strengthen the promotion and application of new varieties, new technologies and new models. In recent years, for labor shortage, input increase, to enhance labor productivity, cost saving and efficiency as the goal, accelerate the promotion of orchard mechanization. Promote the construction of production facilities in the park, promote the application of water and fertilizer integration facilities, establish water and fertilizer saving application mode, and cooperate with water and fertilizer application according to the law of crop and fruit tree growth and development. Promote the application of self-propelled spraying, fertilizing, mowing, operating platforms and other machinery, and carry out trials and demonstrations of unmanned aircraft flight prevention, and other orchard unmanned intelligent machinery. To precise production, improve the level of information technology as the goal, accelerate the application of Internet of things, big data, artificial intelligence, information technology. Establish automatic collection and transmission equipment for environmental meteorological factors in the park, and automatic monitoring equipment for diseases and insects. Install production process visualization equipment, guide and encourage production subjects to dock with the information platform of Feng County Big Data Center, upload production information, product information and demand information in a timely manner, and improve the overall information management level.

### 4.4 Sustainable Monitoring Technology Application

Through sustainable monitoring, the growth state of pear trees and the environmental changes can be better understood more accurately, so that management measures can be formulated efficiently and the impact on the ecological environment can be minimized. The sustainable monitoring of pear trees mainly refers to the growth status of pear trees, the occurrence of diseases and pests, soil fertility and other key indicators for regular tracking and monitoring, in order to ensure the healthy growth and high-quality yield of pear trees, and to

explore efficient and environmentally friendly management measures. The monitoring contents includes: pear tree growth status, disease and pest occurrence, soil properties, soil fertility, moisture monitoring and yield and quality, etc. The monitoring results are fed back to the platform in real time, which helps the technicians and fruit farmers to consider the above factors comprehensively and take necessary adjustments and measures in time for the suitable growth conditions and the best yield and quality needs, which will help to realize the sustainable monitoring and management of pear trees. In addition, the role of sustainable monitoring of pear trees is multifaceted, which not only helps fruit farmers to better manage pear trees and improve the yield and quality, but also plays a positive role in promoting environmental protection and sustainable development.

## 5 Socio-economic Development and Historical Traditions

### 5.1 Population and Socio-economic Development

According to the Seventh National Census, in 2020, Feng county's urban population was 600,000 people, accounting for 49.82% of the region's population; the rural population was 604,300 people, accounting for 50.18%. It can be seen that the urban population of Feng county increased by 17.03%, the rural population decreased by 7.34%, and the proportion of urban population increased by 13.20% in ten years. In 2020, the GDP of the county is 48.653 billion Yuan, the added value of primary industry is 9.640 billion Yuan, and the proportion of added value of primary industry to GDP is 19.81%. The annual fruit tree planting area is 30,063 ha, and the pear planting area is 4,686 ha; the annual fruit output is 68,016 tons, and pear output is 132,500 tons. Compared with 2010, the GDP of Feng County in 2020 increased by 223.96%, and the added value of primary industry increased by 177.57%. During 10 years, the area planted with fruit trees in the county decreased by 1.15%, the area planted with pears decreased by 6.28%, and the output increased by 19.50% (Table 10).

**Table 10** Statistics on population and agricultural economic changes in Feng county (2010–2020)

	Urban population (million)	Rural population (million)	Total production value (million Yuan)	Added value of primary industry (million Yuan)	Area of fruit trees (ha)	Fruit production (tons)	Pear area (ha)	Pear production (tons)
2010	51.27	65.22	150.18	34.01	30,414	520,090	5,000	110,880
2020	60.00	60.43	486.53	96.40	30,063	680,016	4,686	132,500
Increase or decrease	8.73	-4.79	336.35	60.39	-351	159,926	-314	21,620
Change rate (%)	17.03	-7.34	223.96	177.57	-1.15	30.74	-6.28	19.50

### 5.2 Historical Development of Forestry and Fruit Industry

Due to the historical flooding of the Yellow River water in Feng county up to many times, it resulted in leaving 450,000 mu (=30,000 ha) of sand wasteland in the area, with sandy and soaking sandy soil accounting for 70% of the total arable land area<sup>[6]</sup>. At the beginning of liberation, the Feng county government, in order to fundamentally improve the ecological environment of the county, planted trees and fruits, and carried out the construction of orchards<sup>[54]</sup>. In 1962–1968, the young people went down to Dashahe orchard and participated in the construction of orchards, they personally carried out fruit tree planting, pruning, spraying, and other production activities, under the blazing sun, cold and sand, and dedicated their youthful years to build a number of large-scale orchards. In 1980s, Feng county vigorously develop white pear and other economic forests, along the waste Yellow River, Dasha River on both sides of the 300,000 mu (=20,000 ha) of high-quality fruit production base. Into the 21st century, continue to green the forestable land, four along the land, accel-



erate the economic forest update, optimize the planting structure, since 2013, the promotion of Sucui 1 early pear and other new varieties, the construction of standardized demonstration garden more than 30, demonstration to lead the development of modern orchards.

After decades of unremitting efforts, Feng county trunk highways, backbone rivers, major rivers, branch rivers and large ditches have been high standard, high quality greening, basically achieved the “strip of road shade, block farmland forest network, river channel forest belt, every village forestry”. It has been awarded the titles of National Plain Greening Advanced County, National Sand Control Advanced County, China’s Hometown, National Top Ten Fruit Production County, National Export Fruit Demonstration Area, National Ecological Demonstration County, National Agricultural Tourism Demonstration Point, National Greening Model County, and also named as “Green Industry Demonstration Area” by the United Nations Industrial Development Organization.

### 5.3 The Promotion and Transmission of Pear Culture

Feng county of Jiangsu province has a long history of pear culture, with unique local characteristics and cultural connotations. The Centennial Pear Garden is a famous attraction in Lidalou village, Songlou town, Feng county, which is known as a magical, beautiful and mysterious pear garden<sup>[55]</sup>. The pear garden covers an area of 880 mu ( $\approx 58.67$  ha), there are more than 100 ancient pear trees, planted in the Qing dynasty during the Jiaqing period, arranged according to the eight trigrams and nine palaces, with different forms, huge branches and trunks, shaped like swimming dragons, peculiar forms, all year round, with its unique scenery and characteristics, make people forget to return. Centennial Pear Garden is one of the unique tourism resources of Feng county, reflecting the characteristic agricultural culture of the ancient yellow panhandle, representing the long history and humanistic heritage of Feng county. Feng county government and all walks of life are actively carrying out activities such as the pear blossom meeting to promote the development and construction of the pear garden tourism resources, in order to better promote the local agricultural culture and promote the development of the tourism industry.

## 6 Discussion and Conclusion

The case area is located in the ancient Yellow River floodplain areas, influenced by the geographical location, the climatic conditions are very suitable for pear planting, irrigation water source is mainly the Dasha River system, the ecological environment is superior, the unique geographical environment breeds pear products with regional high-quality geographical characteristics. The development of ancient Yellow River floodplain pear cannot be separated from the hard work of Feng county people, enterprise management and supervision and service of the county government. The research of “Case study of ecological environment protection and sustainable development of pear in the Ancient Yellow River Floodplain areas of Feng county” will provide more scientific, efficient and sustainable planting technology and management experience for the pear cultivation industry in the ancient Yellow River floodplain area, further improve pear yield and quality, increase farmers’ income and promote local economic development. In the process of promoting the scientific integration of “green mountains” and “golden mountains”, it is necessary to find a balance between protecting the ecological environment and promoting economic development, and to take measures such as comprehensive management, fine management, and brand construction to achieve win-win social, economic and ecological benefits. In addition, information flow, logistics, human flow coordination is also vital, need to achieve the synergy of various links, improve the efficiency of pear production, reduce the cost of pear production, to ensure the sustainability of pear production.

### Author Contributions

Zhang, Z. Q. and Song, W. did the overall design of this case and hosted a field workshop on the case in March 2023. Song, W., Zhang, Z. Q., Wang, K., Yang, C. L., Gao, F. Y., Xu, X. L., Duan, Y. Q., Shi, W. J., Li, D. H., Li, X. B., Li, B. F., Hou, L. Y., Yu, H., Sheng, S. Q. and Wei, X. participated in the case study fieldwork, Gao, F. Y. provided and developed the statistical data, Li, X. B., Li B. F. and Hou, L. Y. provided the enterprise management data, and Song, W., Zhang, Z. Q., Shi, W. J., Gao, F. Y., Li, D. H., Yu, H., Sheng, S. Q. and Wei, X. conducted soil testing and water sample collection. Zhang, Z. Q. and Song, W. provided guidance for the case study, and Yu, H., Sheng, S. Q., Li, S. C. and Wei, X. participated in the writing of the paper.

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### Conflicts of Interest

The authors declare no conflict of interest.

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