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GIES Case Dataset on Panshi Large Corylus Low Mountain and Hills in Futai Town, Jinlin Province of China

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Abstract: The quality, taste, and brand of ecological products are naturally connected to their geographical origins. Hazelnut, a typical ecological product, is closely related to the geographical environment and socio-economic conditions. High-quality development of its industry can effectively sustain environment and promote rural revitalization. The Panshi large hazelnut (*Corylus heterophylla*×*C. Avellana*), planted in Futai town, Panshi city, Jilin province, is one of the products of eco-geographical and environmental protection concern and represents a sustainable development case in the low mountain hills. Futai town is located in the transition zone between the Songliao Plain and the Changbai Mountains, belonging to mid-temperature humid monsoon region. The precipitation of the town is abundant, and the quality of the water for irrigation of hazelnut plantation is better than that of national standard on Type II water reserve for the urban residents. The soil is weakly acidic, and the main types are Gray Brown Soil, Albic Soil, and Alluvial Soil. The soil quality is better than the screening value of the soil pollution risk of agricultural land. The region's natural environment is suitable for large hazelnut planting and management. The large hazelnut planted in Futai town is *Corylus heterophylla*×*C. Avellana*, including several cultivars, such as Dawei (84-254), Yuzhui (84-310), and Liaozhen No.7 (82-11). The dataset of the case study is archived in five folders: boundary data; geographical data; product attribute data;

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management data; and photos. The dataset is stored in .shp, .tif, .xlsx, .docx, .txt, and .jpg formats, and is 17.9 MB in size.

Keywords: Panshi city; Futai town; *Corylus heterophylla*×*C. Avellana*; low mountain hills; GIES Case 11

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CSTR: https://cstr.escience.org.cn/CSTR:20146.14.2021.04.07

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.2021.12.46.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2021.12.46.V1.

1 Introduction

With the rapid development of China's economy, the demand for high-quality agricultural products is on the rise. In this context, "products with certain geographic features" have been paid unprecedented attention, including geographical indications, featured geographical products, and traditional geographical products[1,2]. At present, the concept of "Lucid waters and lush mountains are invaluable assets" (the "two mountains" initiative) is deeply rooted in the hearts of people and has been continuously put into practice. Ecological products are an important starting point to substantiate the 'two mountains' initiative[3]. As one of the four major dried fruits globally, hazelnuts are known as the "King of Nuts" because of their high protein, amino acid content and the anti-cancer chemical paclitaxel[4]. Hazelnuts are also an important ecological product in great demand in domestic and foreign markets.

The case study area of Futai town is located in Panshi city, Jilin province, in the low mountains and hills of the transition zone between the Songliao Plain and the Changbai Mountains, belonging to the mid-temperate, humid monsoon region. Futai town, a traditional agricultural town, has abundant water and forest resources [5]. Thanks to the high-quality water source such as the Liuyang Reservoir, Futai town has bred Panshi large hazelnuts as a high-quality geographically characteristic product which provides an example of land use in the poor-farmland-converted wood land. As a case of ecological protection and sustainable development in low hilly land, the cultivation, production, processing, and marketing of hazelnuts in Futai town may serve as a useful reference for rural revitalization and ecological civilization construction.

2 Metadata of the Dataset

The dataset of case study is titled the Panshi large corylus Futai low mountain and hills case dataset of ecosystem protection and sustainable development (the Panshi large hazelnut dataset of low mountain hills in Futai town)[6]. The title, author, geographical region, composition of the dataset, publishing and sharing service platform, data sharing policy, and other information pertaining to the case study are shown in Table 1.

3 Case Data Development

The case dataset consists of five folders, including case area location, eco-geographic environment data, product attribute data, business management data and photos. The data of the case dataset is stored in .shp, .tif, .xlsx, .docx, .txt and.jpg formats, with a data size of 17.9 MB.

3.1 Eco-geographical Environment Data

3.1.1 Scope of the Case Area

Futai town of Panshi city is located in the south-central part of Jilin province, 19 km from

Table 1 The metadata summary of the Panshi large corylus Futai low mountain and hills case dataset of ecosystem protection and sustainable development

Items	Description
Dataset full name	Panshi large corylus Futai low mountain and hills case dataset of ecosystem protection and sustainable development
Dataset short name	PanshiCorylusCase11
Authors	Dai, J. H., Institute of Geographic Sciences and Natural Resources Research, CAS, daijh@igsnrr.ac.cn Yang, J., College of Earth Sciences and Resources, Chang'an University, 2020127001@chd.edu.cn Zhou, Y., Institute of Geographic Sciences and Natural Resources Research, CAS, zhouy.19s@igsnrr.ac.cn Fu, J. Y., Institute of Geographic Sciences and Natural Resources Research, CAS, fujy@igsnrr.ac.cn Zhu, M. Y., Institute of Geographic Sciences and Natural Resources Research, CAS, zhumy.16b@igsnrr.ac.cn Song, H. W., Pomology Research Institute, Jilin Academy of Agricultural Sciences, songhw63@163.com Qiao, Y. B., Panshi Agriculture and Rural Bureau, pssnyj@163.com Chen, C. H., Panshi Agriculture and Rural Bureau, 294576808@qq.com Wu, Y. M., People's Government of Futai Town, Panshi City, 771525172@qq.com Chen, B. L., People's Government of Futai Town, Panshi City, 807042432@qq.com Mu, C., People's Government of Futai Town, Panshi City, 624643091@qq.com Song, Y.F., Agricultural Machinery Service Station of Futai Town, Panshi City, 1783404024@qq.com Zhao, J., Fengli Undergrowth cash crop Planting Cooperative of Panshi City, 845008730@qq.com Huang, H. L., Fengli Undergrowth cash crop Planting Cooperative of Panshi City, 845008730@qq.com Zhu, X. G., Beijing Tianhang Create technology Co. Ltd., 18510867688@163.com Liu, C., Institute of Geographic Sciences and Natural Resources Research, CAS, lchuang@igsnrr.ac.cn
Geographical region	The hazel forest located in Futai town, Panshi city, Jilin province, an area of 230 ha
Year	1990–2021
Data format	.shp, .tif, .xlsx, .docx, .txt, .jpg
Data size	17.9 MB
Data files	5 sets of data (case location data, ecological geographical environment data, product attribute data, operation and management data, photos)
Foundations	National Ministry of Science and Technology (2018YFA0606102); China Academy of Sciences Local Cooperation Project
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[7]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

the center of Panshi city. It is between 126°08′E–126°20′E and 42°52′N–43°06′N and with an area of 192 km^2 (Figure 1a).

3.1.2 Physical Geography Features

Futai town is located in the low mountains and hills of the transition ecosystem zone between the Songliao Plain and the Changbai Mountain. Due to tectonic denudation, the hills are mostly rounded, high in the northeast and low in the southwest. The elevation is mostly between 300–460 m, and the slope is between 5°–25°. The highest point is at Nandadingzi Mountain (825 m), and the lowest point is at the southeast of Xiushui village (258 m). The region belongs to the Huifa river basin, including the Futai river, Xinmin river, Lian river, Sijiajie river, and the Nanjin river. The river's total length is 55.06 km, and the drainage area is 15.99 km^2 (Figure 1b). The river network in the hazelnut forest planting area is well

developed, and the ecological conditions are superior, conducive to the growth of *Corylus heterophylla*×*C. Avellana*. The main soil types in Futai town are gray-brown soil, albic soil, and alluvial soil.

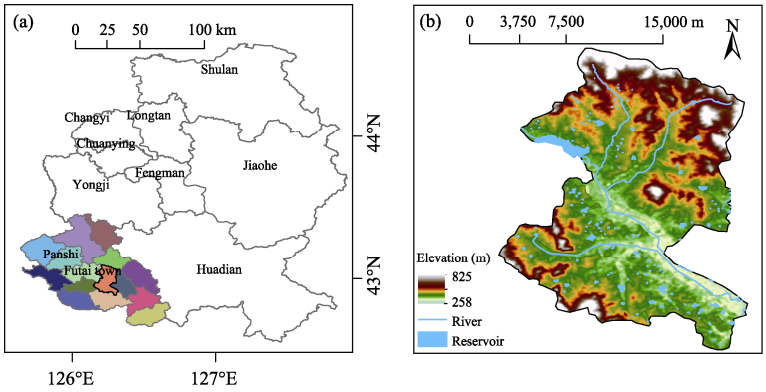

Figure 1 Map of geographical location (a) and topographic water system (b) of the case study area

3.1.3 Meteorological Conditions

The climate data comes from the China surface meteorological daily dataset of the National Meteorological Data Center[1]. The analysis product shows that Futai town has a temperate continental monsoon climate with four distinct seasons, dry and windy in spring, hot and rainy in summer, cool and sunny in autumn, and a long, cold winter. The mean annual temperature of the study area is 5.20 °C, the frost-free period is about 130 days, and the accumulated temperature above 0 °C from April to October is 1,972.9 °C. The mean annual precipitation is 723.4 mm, most of which falls between May and September, when the average total precipitation and daily relative humidity are 576.8 mm and 69.05%, respectively. The annual mean wind speed is 1.99 m/s. The mean and annual sunshine hours are 6.35 h and 2,318.27 h, respectively (Figure 2).

In order to find the relationship between plant distribution and climatic factors, we calculated the Warmth Index (*WI*) to serve as the heat index for the growth of *Corylus heterophylla*×*C. Avellana* [8]. A normal distribution analysis from 1990 to 2019 shows that the regional optimum Warmth Index was 105.07–109.13 °C· month, and 40% of the years fell within in this range (Figure 3a). The Warmth Index was at a minimum in 1993 (101.27 °C·month) and reached its maximum in 1998 (117.51 °C·month). The annual mean Warmth Index ($\overline{WI}$) is 107.60 °C·month and the Standard Deviation (*SD*) is 3.86 °C·month (Figure 3b). According to the relationship between the distribution of representative plants in the temperate zone of China and the Warmth Index[9,10], the temperature in Futai town are favorable for the growth-of *Corylus heterophylla*×*C. Avellana*.

3.1.4 Soil Physical and Chemical Properties

The soil samples were collected from the large hazelnut planting area in the study region with nine sampling sites (Figure 4). Two samples were taken for each sampling sites, at the depths of 30 cm and 40 cm respectively, and a total of 18 samples were taken for this study. The carbon-nitrogen content and carbon-nitrogen ratio (C/N) of soil samples were analyzed to reflect soil fertility; soil heavy metal elements were analyzed to assess soil safety. The soil analyses were conducted by the Physical and Chemical Analysis Center of the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, which has a CMA qualification certificate. First, the samples were screened with a 200-mesh soil sieve, and then pulverized with a ball mill. After the samples were dried, the carbon and

[1] China surface meteorological daily dataset. National Meteorological Data Center [OL]. http://data.cma.cn/.

nitrogen contents were analyzed with a total organic carbon/total nitrogen analyzer (Vario TOC Cube). An inductively coupled plasma optical emission spectrometer (ICP-OES) analyzed the content of the trace and heavy metal elements. The test results were shown in Table 2 and Table 3.

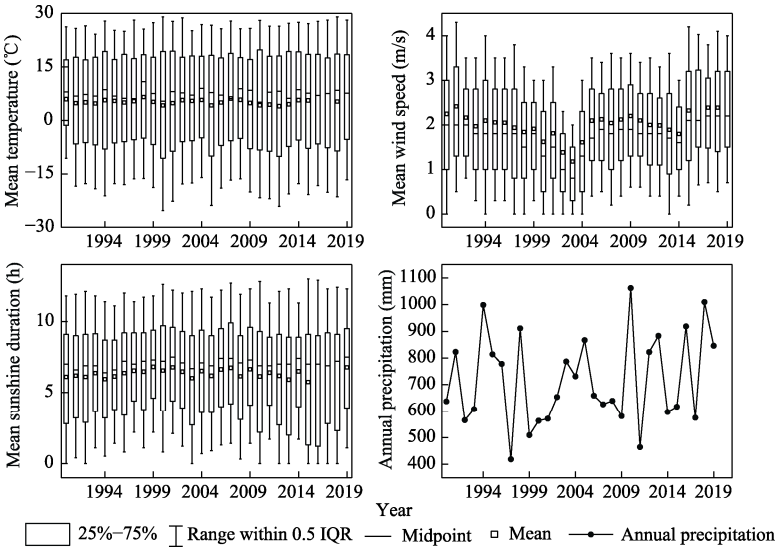

Figure 2 Climatological characteristics of the case area from 1990 to 2019

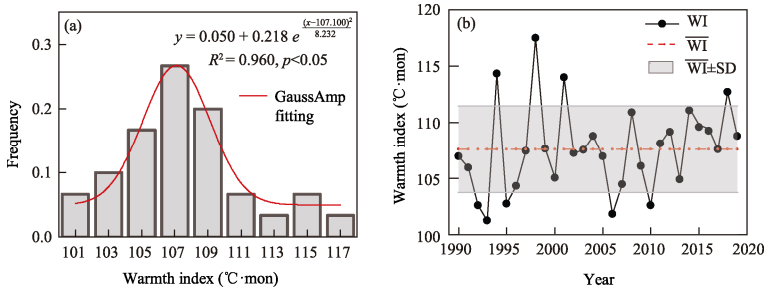

Figure 3 Frequency distribution (a) and interannual variation (b) of the Warmth Index in Futai town from 1990 to 2019

Table 2 Soil carbon and nitrogen content in the case area

Sampling Site	Sampling depth at 30 cm			Sampling depth at 40 cm		
	N%	C%	C/N	N%	C%	C/N
Liuhe village	0.14	1.06	7.63	0.09	0.62	7.16
Liuyang village	0.16	1.50	9.33	0.14	1.27	8.88
Sandaogang village	0.12	1.08	8.72	0.14	1.20	8.57
Yonghe village	0.15	1.40	9.30	0.23	2.36	10.26
Nanyang village	0.17	1.67	9.74	0.13	1.13	8.65
Dongxin village	0.09	0.66	7.60	0.07	0.55	7.44
Sihe village	0.62	6.52	10.52	0.64	7.00	10.93
North Gold Factory	0.17	1.73	10.28	0.13	1.22	9.04
Jiangjia village	0.29	3.41	11.62	0.15	1.53	9.90
Mean	0.21	2.11	9.42	0.19	1.88	8.98
Standard deviation	0.16	1.82	1.32	0.17	1.99	1.24

The data showed that the soil from Futai town is weekly acidic. Among the 18 soil samples tested, the nitrogen (N) content is about 0.07% to 0.64%, the carbon (C) content is about 0.55% to 7.00%, and the C/N is between 7.16 and 11.62. The average carbon (C) contents of the nine villages at 30 and 40 cm sampling depths are 2.11% and 1.88%, respectively, and the nitrogen (N) contents are 0.21% and 0.19%, respectively. The ratios of C and N are 9.42 and 8.98, respectively. The spatial difference of soil C and N content and their ratio is small, and the organic carbon and nitrogen content and the ratio of C and N in the surface soil are higher than those in the bottom soil. The soil samples from Sihe village have the highest carbon and nitrogen content, and the soil samples from Dongxin village have the lowest carbon and nitrogen content. The contents of heavy metals Arsenic (As), Chromium (Cr), Copper (Cu), Nickel (Ni), Lead (Pb), and Zinc (Zn) in the soil are within the limits of the soil pollution risk screening value of agricultural land[11].

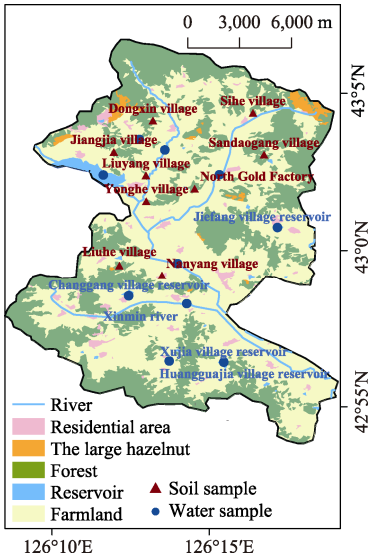

Figure 4 Map of soil and water samples locations

Table 3 The soil metal contents versus the screening value of soil pollution risk in agricultural land[11]

Sampling sites	Sampling depth (cm)	As (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
Screening value [11]	–	40	150	150	60	70	200
Liuhe village	30	4.89	63.35	15.96	32.96	24.31	97.43
	40	7.75	65.42	18.59	29.86	21.40	90.17
Liuyang village	30	15.70	64.56	21.92	28.61	20.93	103.80
	40	5.42	65.64	21.72	30.19	16.53	97.39
Sandaogang village	30	7.40	59.29	10.37	29.45	31.53	106.90
	40	7.25	57.08	9.27	28.29	30.51	105.60
Yonghe village	30	7.04	60.37	17.40	30.97	22.69	93.38
	40	11.37	64.62	16.53	29.75	23.97	108.50
Nanyang village	30	15.61	69.43	20.09	31.69	28.20	96.92
	40	18.58	62.81	18.97	32.22	29.79	98.17
Dongxin village	30	14.85	62.96	13.71	29.22	37.10	92.88
	40	16.56	67.67	13.45	30.13	36.60	94.62
Sihe village	30	7.50	61.01	17.75	29.41	30.59	119.30
	40	11.65	58.08	17.47	28.00	29.79	119.00
North Gold Factory	30	7.87	69.29	15.96	29.80	27.21	108.90
	40	10.91	68.63	15.50	29.34	20.25	107.10
Jiangjia village	30	14.24	60.38	14.20	29.97	19.97	106.80
	40	1.65	57.10	11.60	28.57	21.15	89.82

3.1.5 Water Quality

We selected ten water sampling sites in the case area (Figure 4). The content of arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), phosphorus (P), lead (Pb), and selenium (Se) were determined by atomic emission spectrometry, and atomic fluorescence was also used to determine mercury (Hg) content. We used an inductively coupled plasma optical emission spectrometer (ICP-OES) and an atomic fluorescence spectrometer (AFS) to conduct the detection, respectively (Table 5)[2]. In comparison to the National Surface Water Environmental Quality Standard (GB 3838—2002) [12] and referring to the project standard

[2] Data were collected from physical and chemical Analysis Center and Spectral Test, Institute of Geographic Sciences and Natural Resources Research, CAS and Pony Testing International Group.

limits (Table 4), eight water samples are considered to be Type I water and meet the water quality requirements of the national nature reserve which respectively come from Liuyang reservoir, Northwest reservoir, Huangguajia village, Jiefang village, Changgang village, Xinmin river, Futai river and Sijiajie river. The Lian river and the reservoir of Xujia village are Type II and III water respectively, which meet the water quality requirements of the Type I and Type II reserve areas for surface water sources of concentrated drinking water. The concentrations of As, Cd, Cr, Cu, Pb, and Se of the ten water samples all meet the water quality requirements of Type I water. As for the P, the Lian River met the Type II water quality requirements.

Table 4 Water quality classification indexes of National surface water environmental quality standard[12]

Surface water environmental quality grade	As (mg/L) ≤	Cd (mg/L) ≤	Cr (mg/L) ≤	Cu (mg/L) ≤	P (mg/L) ≤	Pb (mg/L) ≤	Se (mg/L) ≤	Hg(mg/L) ≤
Type I	0.05	0.001	0.01	0.01	0.01	0.01	0.01	0.00005
Type II	0.05	0.005	0.05	1	0.025	0.01	0.01	0.0005
Type III	0.05	0.005	0.05	1	0.05	0.05	0.01	0.0001
Type IV	0.1	0.005	0.05	1	0.1	0.05	0.02	0.001
Type V	0.1	0.01	0.1	1	0.2	0.1	0.02	0.001

Table 5 Water quality data from the sampling sites of the case study area

No	Sampling site	As (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	P (mg/L)	Pb (mg/L)	Se (mg/L)	Hg (mg/L)	Surface water environmental quality grade
1	Liuyang reservoir	0.007,5	0	0	0.000,2	0.002,3	0	0	0	Type I
2	Northwest reservoir	0.000,4	0	0	0	0	0.001,5	0	0	Type I
3	Xujia village	0.004,1	0.000,1	0	0.000,7	0.032,3	0.000,6	0	0	Type III
4	Huangjia village	0	0.000,2	0	0	0.004,2	0.001,2	0	0	Type I
5	Jiefang village	0.006,9	0.000,3	0	0	0	0	0	0	Type I
6	Changgang village	0	0.000,2	0	0	0	0	0	0	Type I
7	Xinmin river	0.002,0	0	0	0	0	0	0	0	Type I
8	Futai river	0	0	0	0	0.002,5	0	0	0	Type I
9	Lian river	0.001,6	0.000,3	0	0.000,3	0.015,9	0	0	0	Type II
10	Sijiajie river	0.000,8	0	0	0	0.004,2	0.000,3	0	0	Type I

3.2 Product Attributes

3.2.1 The Large Hazelnut

The large hazelnut in this case refers to the main cultivars of *Corylus heterophylla*×*C. Avellana*, including Dawei (84-254), Yuzhui (84-310), and Liaozhen No.7 (82-11). It is an excellent breed from a distant hybridization between *Corylus heterophylla* and *Corylus Avellana*. The large hazelnut retain the original excellent genes of *C. heterophylla* and *C. Avellana*, which have the characteristics of strong adaptability and flavor from *Corylus heterophylla*, and the high yield and high kernel rate from *Corylus Avellana*[13]. These cultivars are bred by the Economic Forest Research Institute of Liaoning Province. The first batch of cold-resistant hybrid cultivars bred in 1999 mainly included Pingdinghuang, Bokehong, Dawei, Jinling, Yuzui, etc.; in 2000, another 29 excellent hybrid lines were selected. *Corylus heterophylla*×*C. Avellana* usually bloom in early April, and the flowering period is 10–15 days. The tree bears fruit in late May and matures from the end of August to the beginning of September, experiencing a fruit growth period of over 100 days. The growth cycle is more than 40 years. Generally, for the newly built fruit gardens, corylus trees can bloom and bear fruit in three years, and it enters the full fruit period in about seven years[14].

The characteristics of the main cultivars of *Corylus heterophylla*×*C. Avellana* are as follows[15,16] (Figure 5).

(1) Dawei (84-254): The tree is strong and upright. The nut is oval-shaped, with an average fruit weight of 2.6 g. The shell is brown, and the shell thickness is 1.5 mm. The kernels are smooth and plump with good flavor. The peeling rate is 70%, and the kernel rate

Figure 5 Morphology of three cultivars of *Corylus heterophylla*×*C. Avellana*

is 42%–44%. Trees of Dawei cultivar have a strong overwintering ability and can resist temperatures as low as –35 °C in the dormant period. It is suitable for cultivation in areas that have an annual mean temperature warmer than 4 °C

(2) Yuzhui (84-310): The tree is strong and upright, and the crown is large. The nut is long cone-shaped, with an average fruit weight of 2.0 g. The shell is dark red, and the shell thickness is 1.15 mm. The kernels are smooth and its plump has good flavor. The peeling rate is 70%, and the kernel rate is as much as 43%. Trees of Yuzhui cultivar have strong cold resistance and can resist temperatures as low as –35 °C in its dormant period.

(3) Liaozhen No.7 (82-11): The tree is moderately vigorous with open crown. The nut is conical. The shell is reddish-brown and of medium thickness. The kernels are smooth and plump has good flavor, and the kernels fall off easily. The kernel rate reaches 40%. Trees of Liaozhen No.7 cultivar have a strong overwintering ability and can resist temperatures as low as –35 °C in the dormant period. It is suitable for cultivation in Northeast China with snow cover in winter and an annual rainfall of more than 700 mm.

3.2.2 Biological Characteristics of *Corylus heterophylla*×*C. Avellana*

The *Corylus heterophylla*×*C. Avellana* is a 1–7 m tall deciduous shrub or small tree of the genus corylus of the Betulaceae family. Its bark and branches are dark gray and glabrous, while the twigs are tawny with pubescent and spiny glands. The leaves of corylus are oblong or broadly obovate in outline and 4–13cm long. The leaf base is heart-shaped, sometimes with unequal sides. The edges of the leaves are irregularly serrated. The leaves are lobed above the middle. The leaves have 3–5 pairs of lateral veins, and the petioles are slender. Corylus male inflorescences are solitary and about 4 cm long. The fruit of corylus is subglobose, solitary or 2–6 in clusters, about 7–15 mm long, glabrous or only sparsely villous at the apex. Fruit bracts are campanulate, with slender edges and densely pubescent and spiny glands. The peduncle of corylus is about 1.5 cm long and densely pubescent[17,18].

The canopy density of *Corylus heterophylla*×*C. Avellana* is 10%–12%, which can endure cold and thrives in humidity. Hazel is dormant in winter, and the dormancy period is more than 700 h, and it can survive the severe winter temperatures of –30 °C. It is suitable for planting in areas with annual precipitation of 700–1,200 mm. The flowering period is from April to May, and the fruit period is from August to September. Because corylus is a light-loving variety, it should be planted on sunny or semi-sunny slopes with a slope of 5°–25°. Corylus can grow in loam, sandy soil, clay, and lightly saline-alkali soil. The soil texture is either light or medium, the range of pH values is 6.0–7.5, and the gravel content is less than 30%, which is more suitable for the growth of corylus. While corylus is less demanding on topography, it prefers low mountains and hills.

3.2.3 Distributions of Corylus

The most common species of corylus in China are *Corylus heterophylla* and *Corylus mandshurica*, which are distributed in Northeast China and North China. They are mainly concentrated in provinces such as Heilongjiang, Jilin, Liaoning, Inner Mongolia, and Hebei (Figure 6a). In Futai town, *Corylus heterophylla* grows widely in the natural environment. In comparison, the newly introduced *Corylus heterophylla*×*C. Avellana* is mainly planted in the east hill of the Houziran village to the northeast, along the northwest slope of Xibei village, the west hill of the Hongshi village to the northwest, the east hill of Sijia village to the north, the north slope of Ziyou village and the east hill of Tudingzi village in the central

area, the east hill of Xigou village, and the east hill of Changgang and Jiefang villages to the south (Figure 6b).

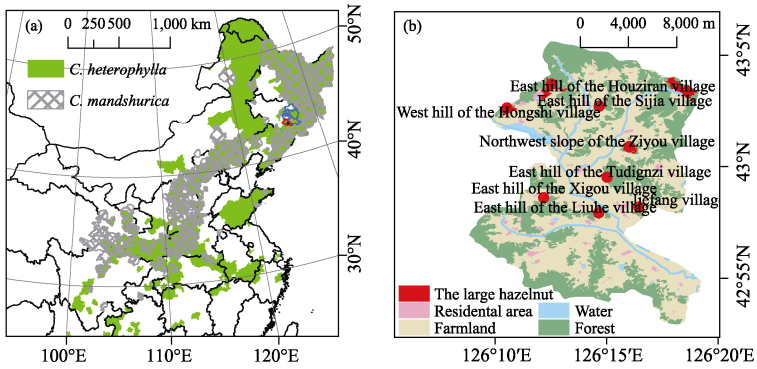

Figure 6 Distribution of *Corylus heterophylla* and *Corylus mandshurica* in China (a) and cultivation of corylus in Futai town (b)

3.2.4 Nutritional Composition of Large Hazelnut

Here, we compared the three cultivars of *Corylus heterophylla*×*C. Avellana* from Panshi with the corylus produced by Tonghua, Nuts Zhang and the corylus nutrient content standard issued by the United States Department of Agriculture (USDA). The evaluation indicators include energy, protein, fat, carbohydrates and sodium. The content test results refer to the National food safety standard GB 5009.5—2016[19] to determine the protein, fat and sodium content; and refers to the Basic terminology of food nutrients GB/Z 21922—2008[20] to determine the energy and carbohydrate content (Table 6). Results indicate that in each 100 g case product, the average content of energy, protein, fat, and carbohydrates for the three kinds of corylus (Dawei, Yuzhui, and Liaozhen No.7) produced in Futai are 2,669.3 kJ, 21.0 kJ, 54.1 g, and 18.3 g, while the average Nutrient Reference Values (NRV)[3] of Chinese food labels are 31.7%, 35.0%, 90.3%, and 6.3%, respectively. Compared with the corylus produced in Tonghua, the three cultivars from Panshi have more energy and protein; compared with the Dried Fruit Zhang, they have more protein and carbohydrates, and fewer lipids; compared with the USDA standard, they have more energy, protein, and carbohydrates, and fewer lipids.

Table 6 Nutrient composition comparison of different *Corylus heterophylla*×*C. Avellana* products

Products	Projects	Energy	Protein	Lipids	Carbohydrates	Sodium
Dawei (84-254)	Per 100 g	2,681 kJ	20.4 g	55.0 g	17.6 g	0 mg
	NRV%	32%	34%	92%	6%	0%
Yuzhui (84-310)	Per 100 g	2,640 kJ	20.5 g	52.5 g	20.5 g	0 mg
	NRV%	31%	34%	88%	7%	0%
Liaozhen No.7 (82-11)	Per 100 g	2,687 kJ	22.1 g	54.7 g	16.9 g	0 mg
	NRV%	32%	37%	91%	6%	0%
Tonghua	Per 100 g	2,668 kJ	19.3 g	54.1 g	19.9 g	0 mg
	NRV%	32%	32%	90%	7%	0%
Nuts Zhang	Per 100 g	2,825kJ	20.8 g	60.3 g	14.1 g	0 mg
	NRV%	34%	35%	100%	5%	0%
USDA	Per 100 g	2,625 kJ	14.95 g	60.75 g	16.70 g	0 mg
	NRV%	31%	25%	100%	6%	0%

3.3 Product Management

3.3.1 Socio-Economic Infrastructure

Futai town covers an area of 192 km^2, and governs one community, 14 administrative

[3] Nutrient Reference Values, NRV. http://www.gov.cn/gzdt/2008/01/11/content_856260.htm.

villages, and 47 natural villages, with a total population of 10,432. The total area of farmland is 9,715 ha, and the total annual output of grain is 110,000 tons. The region is rich in forestry resources, with a total area of 19,402 ha. The forested area is mostly natural forest, with a small amount of shelter forest, economic forest, and fruit trees. The dominant species of natural forests include *Larix olgensis, Pinus koraiensis, Pinus sylvestris, Populus przewalskii, Salix babylonica, Quercus mongolica, Juglans regia, Styphnolobium japonicum, Betula platyphylla, Fraxinus mandshurica,* and so on; fruit trees include apple trees, apricot trees, plum trees, and so on. During the "Thirteenth Five-Year Plan" period, the social fixed assets of Futai town accumulated 1.6 billion Yuan, the total output value of large-scale industries was 1.8 billion Yuan, and the full-scale fiscal revenue was 23.5 million Yuan. Futai town has been awarded the demonstration township of the rule of law, the province's advanced legal service station, and the civilized township of Jilin City. Nanchanggang Village and Changgang Village were awarded the title of the National demonstration village of democracy and the rule of law and the Provincial demonstration village of democracy and the rule of law. In 2020, Dongxin Village was awarded the title of "One Village One Product" demonstration village in Jilin province. In 2021, Futai town was honored to be selected as the second batch of national rural governance model towns by the Central Agricultural Office, the Ministry of Agriculture and Rural Affairs, the Publicity Department, the Ministry of Civil Affairs, the Ministry of Justice, and the National Rural Revitalization Bureau. The planting area of the hazel trees in Futai town is 230 ha. According to the hazel tree row spacing of 3 m × 3 m, 1,100 hazel trees can be planted per hectare, allowing a total of 253,000 hazel trees to be planted in Futai town. If the fifth year yield is 5,250 kg/ha, the estimated total hazelnut yield will be 1,207.5 t.

3.3.2 Operation and Management of Large Hazelnut

Although Futai town has favorable conditions for hazelnut planting, the following measures still need to be taken:

(1) Promote in-depth industry-institute-university-government cooperation: The Institute of Geographic Sciences and Natural Resources Research of the Chinese Academy of Sciences has officially signed the "Framework Agreement on Science and Technology Cooperation" with the Panshi Municipal Government, which is favorable for the in-depth development of industry-university-research cooperation and should continue to be maintained.

(2) Strengthen the leading role of professional cooperatives: led by Panshi Fengli Professional Cooperative, 293 farmers in 4 parks of 9 villages, including the Sihe and Sandaogang villages, participated in the development of planting of large hazelnut. Now there are 27 members of the cooperative, equipped with a wind selecting machine, peeling machine, sealing machine, and other equipments. The cooperative was registered as a trademark brand in 2018. In 2020, the collective income of nine villages had increased by nearly 200,000 Yuan. To increase farmers' income, we have applied under- tree-economy, planting more than 10 ha of Chinese medicinal plants such as *Pulsatilla chinensis, Taraxacum mongolicum, Clematis chinensis* under the trees, increasing the output value by more than 300,000 Yuan.

(3) Establish a germplasm resource bank and strengthen breeding: due to the low economic value of natural corylus, the distribution of wild hazelnut plants has shrunk, and some precious germplasm is being lost. Germplasm resources protection banks have been established in more than 20 countries and regions globally[21], most of which are *Corylus avellana L.*, *Corylus yunnanensis,* and *Corylus ferox.* Although this has protected some corylus germplasm resources, the fine corylus cultivars are still very limited. Therefore, to further promote planting, improve the quality of hazelnuts, and increase yield, more germplasm resource banks should be established. In this way, we can continue to strengthen scientific breeding and improve breeding techniques.

(4) Take professional field management measures: *Corylus heterophylla*× *C. Avellana* is a heliophile species characterized by strong resistance to adversity. The suitable range of soil pH values for corylus is 6.0–7.5, and it can be planted on gentle slopes, flat land,

water-repellent land, or sandy land[22]. To increase the yield of *Corylus heterophylla*×*C. Avellana*, the ideal fertilization time is during the slow growth period (April 15 to May 15), and the topdressing (the second best fertilization time) is applied at the end of the second rapid growth period (after June 15). As for pruning, the cultivated tree shapes include two types, the plexiform with less stemmed the and single stemmed. Pruning the large hazelnut of different ages has different pruning measures[23]. The soil management methods include deep plowing and expansion, tillage, intercropping, soil loosening and weeding, clearing tillage, and grass growing. In addition, attention should be given to prevent and control diseases and insect pests.

3.4 Tradition and Inheritance Culture

Hazelnut has a long history as a food source in China. There were many hazelnut husks in the Banpo Yangshao Cultural Site in Xi'an, which shows that they had been used for five to six thousand years[24,25]. In addition, there were also abundant records of the cultivation and utilization of hazelnut in the ancient Chinese Materia Medic. For example, the medicinal values of hazelnut were described in detail in Compendium of Materia Medica edited by Li, Shizhen in the Ming dynasty[26], and also in some Regional Chronicles. The biological characteristics of hazelnut was explained in some specialized works on plants in ancient times, e.g., An Illustrated Book on Plants[27], and A Lengthy Compilation of Illustrated Book on Plants[28], both edited by Wu, Qijun who was an official and once the Number One Scholar in the Qing dynasty. According to ancient records[26–28], Northeast China and North China were also important distribution centers of corylus[29].

Hazelnut was considered a popular gift among Chinese literati in ancient times, and there were many vivid descriptions of this in the literary works of the past dynasties. It is worth noting that hazelnut was chanted in many ancient Chinese poems, including poems inside The Book of Songs edited in the Spring and Autumn Period, in many previous dynasties, such as the Tang, the Song, the Ming, as well as the Qing dynasty. As Jilin province was the ancestral home of the emperors of the Qing dynasty, there are many historical books recording the historical geography of this region. The name of Futai town came from the Futai River, and the name of the river was derived from the Manchu language "*Fudohe*" or "*Fuerha*"[30]. The former meant willow, and the latter meant poplar. It showed that the local eco-geographical environment was excellent throughout history.

4 Sustainability of Case Study Area

4.1 Establishment of a Long-term Habitat Monitoring System

An automated habitat observatory was built to better monitor *Corylus heterophylla*×*C. Avellana* ecological conditions in March 2021 in Zhonghe village, Futai town. The observatory is a low-power Internet of Things (IoT) sensing system that can automatically recognize and record various environmental factors in real time, including the visible landscape, meteorological elements, air, soil, water quality, vegetation, phenology and pests. The system can carry out automatic data collection around the clock, and more observation sites will be built in the future.

4.2 Consolidate the Achievements of Returning Farmland to Forests, and Strictly Adhere to the Red Line of Cultivated Land

The Large Hazelnut is an important ecological and economic species, which can protect the environment and increase economic benefits. At present, Futai Large Hazelnut is all planted in the area of returning farmland to forests, and there is no intersection with the farmland. This is also an important manifestation of sustainable production and operation. In the subsequent development of the hazelnut industry, we must strictly observe the red line of farmland, and guide villagers to cultivate the hazel forest in an orderly manner to promote sustainable economic development.

5 Discussion and Conclusion

Futai town is in the environment of low mountains and hills of the transition zone between the Songliao Plain and the Changbai Mountains. The excellent geographical environment has cultivated high-quality geographically characteristic products in Futai town. In this case study, the municipal government of Panshi cooperates with the Institute of Geographic Science and Natural Resources Research of Chinese Academy of Sciences to make full use of the scientific and technological advantages to improve the livelihood of the local people.

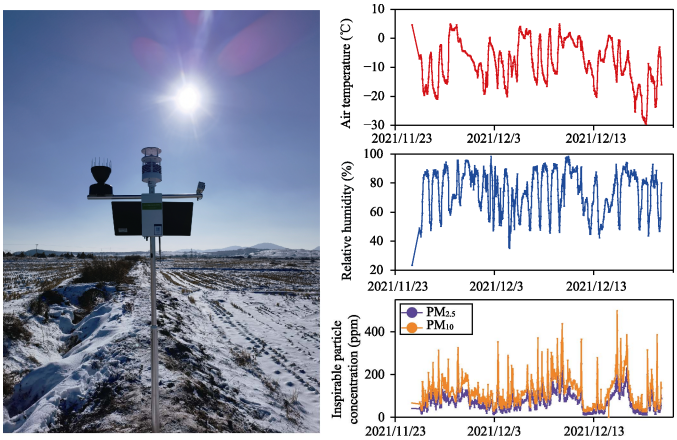

Figure 7 Ground stations and observed real-time eco-geographical environment data

Through the organic combination of habitat protection and sustainable development of high-quality geographical products, the members of the Panshi Sharp Cooperatives led the villagers to promote green planting and realize the unity of science, technology, and market under the principle of improving livelihoods. The adoption of scientific theory, engineering technology, and management modes have important reference value, which will provide valuable practical experience for promoting local economic development, environmental protection, and ecological benefits.

Based on the real-time monitoring system and the strengthened phenological observations, a reliable yield prediction model will be developed to make major breakthroughs in technology[31,34]. Currently, the hazelnut's nutritional and reproductive phenology records such as leaf expansion, flowering, fruit hanging, and fruit ripening are still a little weak. The occurrence times of key phenological periods, the accumulated temperature required for hazelnut development and fruit yield under different environmental conditions can be predicted by phenological observation.

Author Contributions

Dai, J. H. and Liu, C. are responsible for the overall design and the dataset development. Dai, J. H., Yang, J., Zhou, Y., Fu, J. Y and Zhu, M. Y. wrote the manuscript. Yang, L. H., Song, H. W., Qiao, Y. B. and Chen, C. H. processed the data. Wu, Y. M., Chen, B. L., Mu, C., Song, Y. F. and Huang, H. L. conducted sampling and household survey. Zhu, X. G. provided and processed real-time monitoring data. Dai, J. H. and Liu, C. finalized this data paper.

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Conflicts of Interest

The authors declare no conflicts of interest.

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