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GIES Case Study on Le'an Bamboo Shoots Subtropical Mountains

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Abstract: Le'an County is located in the southwest of Fuzhou City and central part of Jiangxi Province of China. It is surrounded by mountains and has a terrain that is high in the south and low in the north. It belongs to the subtropical humid monsoon climate zone with warm climate, sufficient sunlight, abundant rainfall and a long frost-free period, which is very suitable for the growth of bamboo. It is systematically analyzed the environment, quality and their internal relations of Le'an bamboo shoots in subtropical mountains by field investigations, indoor testing and so on. Through this study, it is found that the soil where Le'an bamboo shoots grow meets China's national standards and forestry industry standards, and is superior to the European Union's requirements for the soil environment of agricultural land. The water quality is superior to China's standards for drinking water quality and the European Union standard. The excellent ecological environment gives birth to high-quality Le'an bamboo shoots. The GIES (Geographical Indications Environment & Sustainability) case dataset on Le'an bamboo shoots in subtropical mountain consists of boundary of the study area, physical geography, characteristic species, economic and management data, etc. The dataset is archived in .shp, .xlsx, .tif, .pdf, .png and .jpg formats, with data size of 210 MB.

Keywords: Le'an bamboo shoots; subtropical mountains; habitat; sustainability; geographic indications; Case 19

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[2] Yan, L. Y., Yu, L., Ai, Z. F., *et al*. GIES case dataset on Le'an Bamboo Shoots subtropical mountains in Le'an County, Jiangxi Province of China [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2024. https://doi.org/10.3974/geodb.2024.09.10.V1. https://cstr.escience.org.cn/CSTR:20146.11.2024.09.10.V1.

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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.2024.09.10.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2024.09.10.V1.

1 Introduction

As the country with the richest bamboo forest resources in the world, China is one of the largest producers of bamboo shoots[1]. Located in the middle of Jiangxi Province and southwest of Fuzhou City, Le'an County has a subtropical humid monsoon climate with mild climate, abundant sunshine, and ample rainfall, long frost-free period, and distinctive seasons, which is very suitable for the growth of bamboo plants. Bamboo shoots are a regional and healthy delicacy from the mountains. Bamboo shoots have the reputation of "the first vegetarian product" because of rich in vegetable protein and are considered the best organic food. They are not only loved by the countries that produce bamboo shoots but also by people in North America, Europe, and Oceania where has no bamboo[2]. Le'an bamboo shoots are famous for their fresh and tender texture, crisp taste, and fine texture without residue. In September 2011, Le'an bamboo shoots entered the list of the National Geographical Indication Products, and have passed certifications such as "green food", "non-polluted agricultural products", "HACCP" system and the United States FDA, and have won numerous awards such as "Golden Award" at the China Green Food Expo. Le'an bamboo shoots were selected into the directory of China Agricultural Brand in 2019, and the first protection list of the China-EU agreement on geographical indications in 2020[3]. According to the Chinese brand value evaluation results of China Council for Brand Development, the brand value of Le'an bamboo shoots is 1.503 billion CNY as of May 2024.

2 Metadata of the Dataset

The metadata of Le'an Bamboo Shoots subtropical mountains case dataset[4] is summarized in Table 1. It includes the dataset full name, short name, authors, year of the dataset, data format, data size, data files, data publisher, and data sharing policy, etc.

Table 1 Metadata summary of the dataset of Le'an Bamboo Shoots subtropical mountains case

Items	Description
Dataset full name	GIES case dataset on Le'an Bamboo Shoots subtropical mountains in Le'an County, Jiangxi Province of China
Dataset short name	Le'anBambooShootsCase19
Authors	Yan, L. Y., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, yanlingyuan19@mails.ucas.ac.cn Yu, L., Jiangxi Academy of Forestry, yulin0417@163.com Ai, Z. F., The People's Government of Le'an County, Fuzhou City, Jiangxi Province Zheng, J., The People's Government of Le'an County, Fuzhou City, Jiangxi Province Wu, J. G., The People's Government of Le'an County, Fuzhou City, Jiangxi Province Ouyang, J., The People's Government of Le'an County, Fuzhou City, Jiangxi Province Li, R. G., The People's Government of Le'an County, Fuzhou City, Jiangxi Province Yu, B. H., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, yubh@igsnrr.ac.cn Meng, S. W., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, mengsw@igsnrr.ac.cn Wang, H., Le'an Bamboo Shoots Processing Association Chen, G. H., Le'an Bamboo Shoots Group Co., Ltd Chen, G. H., Jiangxi Guangya Food Co., Ltd Yuan, C. M., Jiangxi Dengxianqiao Food Co., Ltd

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Items	Description
	Wang, G. C., Jiangxi Pengxin Food Co., Ltd Zheng, X. G., Jiangxi Lezhifeng Health Industry Co., Ltd
Geographical region	Le'an County, Fuzhou City, Jiangxi Province
Year	1994–2023
Data format	.shp, .xlsx, .tif, .pdf, .png, .jpg
Data size	210 MB
Foundation	The People's Government of Le'an County, Fuzhou City, Jiangxi Province (2024)
Data files	(1) boundary data of the case area; (2) physical geographical conditions (including climate, water, soil, etc.); (3) characteristic species; (4) economic and management, etc.
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	(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[5]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC

3 Case Area

Le'an bamboo shoots in subtropical mountains case area covers area of Le'an County, which is the geographical center of Jiangxi Province. It is located to the east of Chongren County, Yi huang County, to the west of Yongfeng County, Xingan County, to the north of Fengcheng City, and to the south of Ningdu County. The total area of the county is 2,412.59 km^2. Its geographical region of 115°35′E–116°10′ E and 26°50′N–27°45′ N (Figure 1). The case area covers the core production area of Le'an bamboo shoots, including seven towns of Nancun, Gugang, Zhaoxie, Aoxi, Gongxi, Huxi and Jinzhu.

4 Ecological and Geographical Environment

4.1 Topography and Climatic Characteristics

Le'an County is surrounded by mountains, with undulating hills and numerous peaks scattered like stars and chess pieces. The overall terrain is higher in the south and lower in the north, presenting an irregular shape that is longer from north to south and narrower from east to west. The southeastern part is a mountainous area, characterized by overlapping peaks and crisscrossing ravines; the northern part is a hilly area, with rolling hillocks and a relatively lower and flatter terrain than the southeast (Figure 2, Figure 3).

Le'an County is located in the transition zone between South China climate zone and Central China climate zone, which belongs to the humid subtropical monsoon climate zone. Warm and cold vary in spring. Summer is hot and rain is concentrated. Autumn is cool, more drought and less flood. Winter is cold with strong north wind. According to the data of National Meteorological Information Centre, the average temperature of Le'an County from 1994 to 2023 is 18.2 °C, the average annual precipitation is 1,757.7 mm, there is more rain in spring and summer, and the annual average sunshine duration is 1,557.7 h (Figure 4–9).

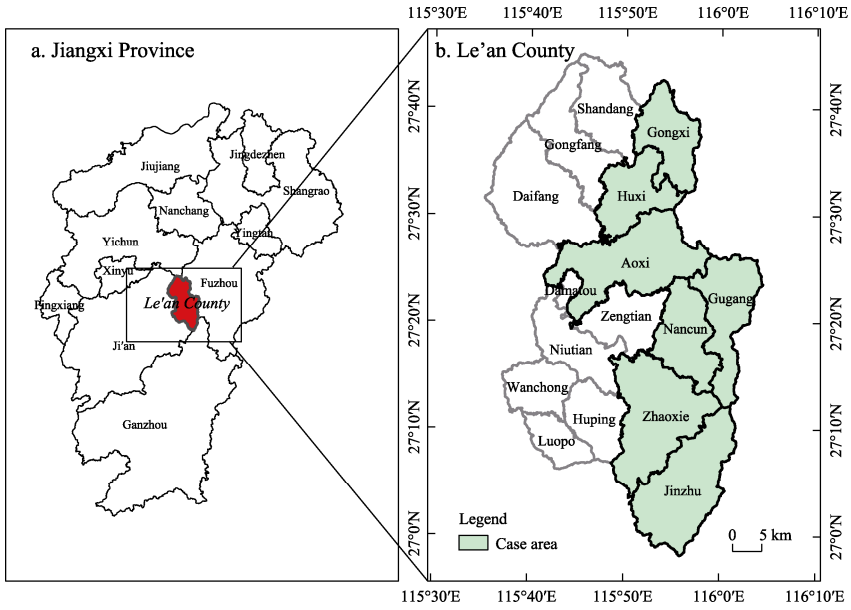

Figure 1 Map of Geo-location of the case area

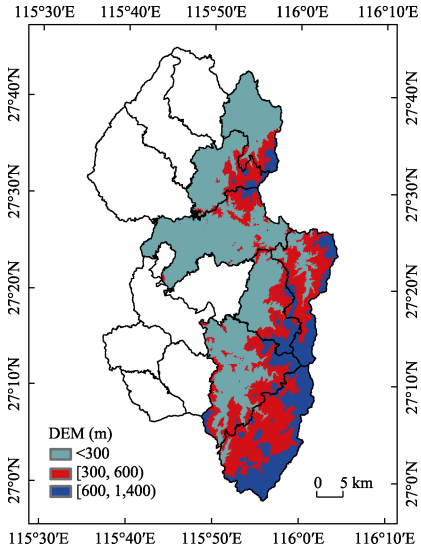

Figure 2 Map of DEM classification of the case area

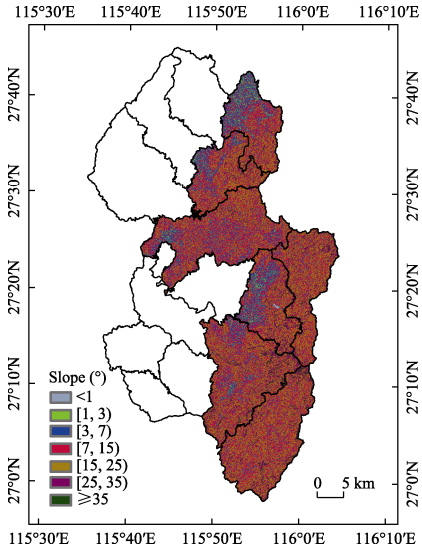

Figure 3 Map of slope of the case area

4.2 Soil Properties

In order to conduct an in-depth study on the soil of the bamboo shoot production area in Le'an, this research collected soil samples from different soil layers based on the distribution of bamboo forests and carried out on the distribution of bamboo forests in the case study area and carried out physicochemical property analysis. A total of 18 sampling points were selected (Figure 10), and soil samples were taken in layers at a depth of 100 cm, with each layer being 20 cm thick. The samples were then sent to the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences for testing. The indicators tested included: soil pH, organic matter content (g/kg), total nitrogen content (g/kg),

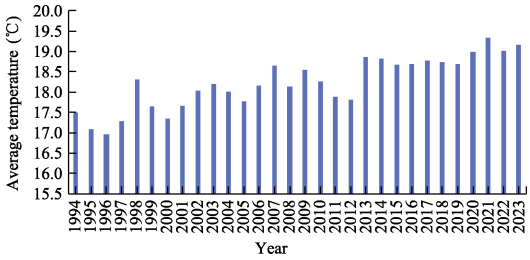

Figure 4 Average temperature (yearly, 1994–2023)

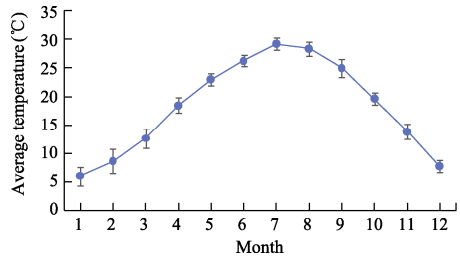

Figure 5 Average temperature (monthly, 1994–2023)

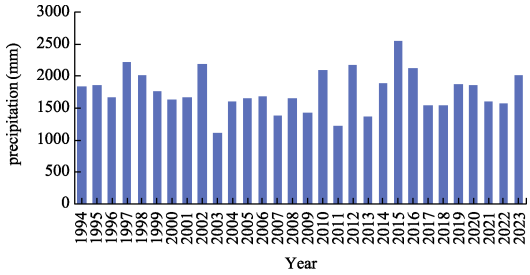

Figure 6 Precipitation (yearly, 1994–2023)

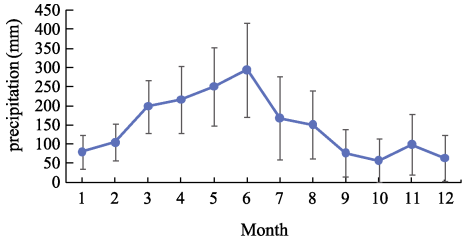

Figure 7 Average precipitation (monthly, 1994–2023)

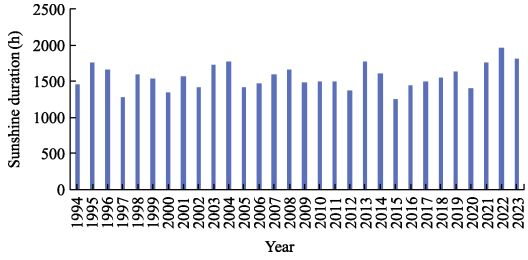

Figure 8 Sunshine duration (yearly, 1994–2023)

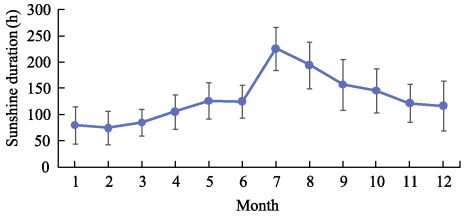

Figure 9 Sunshine duration (monthly, 1994–2023)

and the content of six heavy metal ions—cadmium (Cd), arsenic (As), lead (Pb), chromium (Cr), nickel (Ni), and zinc (Zn) (mg/kg).

The results of the soil sample tests indicate (Figures 11–13) that the average pH of the soil in the case study area is 4.97, with a variation range of 4.41–5.56, which is typical of acidic soil. The average pH of the soil layers at 0–20 cm, 20–40 cm, 40–60 cm, 60–80 cm, and 80–100 cm are 4.83, 4.90, 4.97, 5.03, and 5.10, respectively. Compared to the surface soil, the pH of the deeper soil layers is higher. Both soil organic matter and total nitrogen content decrease with increasing soil layer depth. Among them, the soil organic matter content is the highest in the 0–20 cm soil layer, with an average value of 31.81 g/kg, and the average total nitrogen content is 1.45 g/kg. The minimum of these items all occur in the 80–100 cm

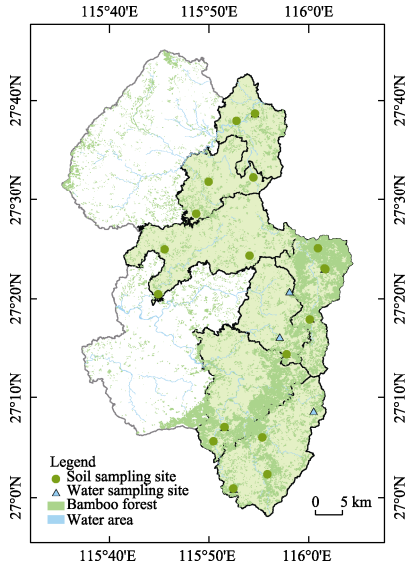

Figure 10 Map of sampling sites in the case area

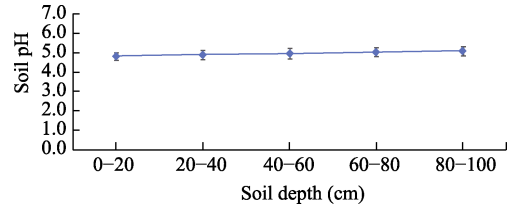

Figure 11 Soil pH in case area

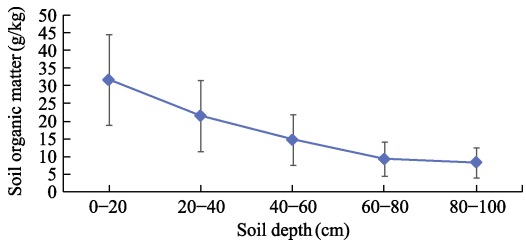

Figure 12 Soil organic matter in case area

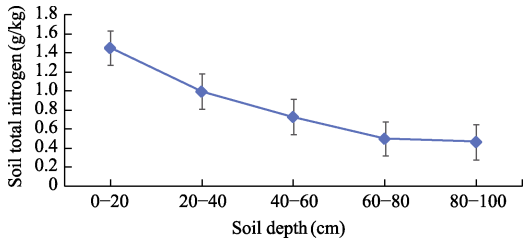

Figure 13 Soil total nitrogen in case area

soil layer, where the average of organic matter and total nitrogen content are 8.34 g/kg and 0.47 g/kg, respectively.

In order to explore the safety of the growth environment for Le'an bamboo shoots, the content of six heavy metal ions—cadmium (Cd), arsenic (As), lead (Pb), chromium (Cr), nickel (Ni), and zinc (Zn) (mg/kg) in the soil was detected and analyzed. The detection basis includes the following: Firstly, according to the forestry industry standard "Environmental general requirements for production area of edible forest product" (LY/T 1678—2014)[6], when the soil pH is less than 6.5, the content of soil cadmium (Cd) ions should be ≤0.3 mg/kg, arsenic (As) ions ≤40 mg/kg, lead (Pb) ions ≤50 mg/kg, and chromium (Cr) ions ≤120 mg/kg. Secondly, according to the national standard "Soil environmental quality risk control standard for soil contamination of agricultural land (Trial)" (GB 15618—2018)[7], when the soil pH is ≤5.5, the content of soil cadmium (Cd) ions <0.3 mg/kg, arsenic (As) ions <40 mg/kg, lead (Pb) ions <70 mg/kg, chromium (Cr) ions <150 mg/kg, nickel (Ni) ions <60 mg/kg, and zinc (Zn) ions <200 mg/kg. Thirdly, considering that Le'an bamboo shoots is on the protection list of China-EU geographical indications agreement, the soil samples were also analyzed against the EU "Soil protection standard for agricultural land (Council Directive 86/278/EEC of 12 June 1986)"[8] which stipulates that the content of soil cadmium (Cd) ions 1–3 mg/kg, lead (Pb) ions 50–300 mg/kg, nickel (Ni) ions 30–75 mg/kg, and zinc (Zn) ions 150–300 mg/kg.

Comparing the soil sample test results (Table 2) with the requirements for soil heavy metal ion content in "Environmental general requirements for production area of edible forest product " (LY/T 1678—2014)[6] and "Soil environmental quality risk control standard for soil contamination of agricultural land (Trial) " (GB 15618—2018)[7], the concentrations of cadmium (Cd), arsenic (As), lead (Pb), chromium (Cr), nickel (Ni), and zinc (Zn) are all below the limit values required by the above standards. Considering that Le'an bamboo shoots were included in the first batch of protection lists of the China-EU Geographical Indications Agreement in 2020, the test results were also compared and analyzed with the EU "Soil protection standard for agricultural land (Council Directive 86/278/EEC of 12 June 1986)", and the soil test results also meet the European requirements for agricultural land soil. The soil conditions in the case study area are excellent and meet the requirements for soil quality in bamboo shoot production.

Table 2 Soil heavy metal content in the case area (mg/kg)

No.	Soil depth (cm)	Cd	As	Pb	Cr	Ni	Zn
No.1	0–20	0.09	2.99	37.10	41.74	18.43	123.05
	20–40	0.06	2.26	31.56	37.88	18.61	122.35
	40–60	0.05	2.09	33.26	36.35	20.68	118.83
	60–80	0.05	2.03	33.72	39.29	23.66	122.75
	80–100	0.03	2.05	32.68	40.12	22.38	131.69
No.2	0–20	0.12	2.87	34.90	15.93	4.37	61.47
	20–40	0.04	2.59	31.19	20.11	5.62	56.64
	40–60	0.06	2.56	33.53	17.45	4.89	61.14
	60–80	0.03	2.20	30.18	12.37	3.65	75.69
	80–100	0.08	2.13	32.22	12.52	4.49	64.39
No.3	0–20	0.09	6.33	23.14	64.13	19.40	63.32
	20–40	0.02	5.98	25.48	62.13	18.85	59.72
	40–60	0.02	5.59	21.49	62.50	15.82	53.08
	60–80	0.03	5.61	25.34	57.69	17.18	58.47
	80–100	0.03	5.91	26.99	57.55	19.23	61.85
No.4	0–20	0.02	3.06	22.51	79.64	37.33	96.23
	20–40	0.03	3.01	23.00	76.41	37.09	94.44
	40–60	0.05	2.96	20.62	72.33	34.10	85.57
	60–80	0.04	3.39	25.82	87.01	46.31	117.99
	80–100	0.04	3.31	26.13	86.94	46.84	114.46
No.5	0–20	0.02	5.46	26.82	30.64	12.18	42.06
	20–40	0.07	5.12	30.78	32.62	13.23	39.84
	40–60	0.01	4.83	24.97	32.30	13.19	40.52
	60–80	0.01	5.82	28.29	35.31	15.05	40.44
	80–100	0.01	5.70	28.86	39.49	16.04	41.67
No.6	0–20	0.12	2.66	25.03	95.38	35.00	98.55
	20–40	0.10	2.46	22.54	95.46	34.90	98.36
	40–60	0.07	2.69	24.64	99.19	43.86	108.78
	60–80	0.09	2.69	26.96	101.15	42.94	110.43
	80–100	0.13	2.67	28.51	95.99	40.43	121.11
No.7	0–20	0.09	3.51	23.93	82.54	35.46	92.44
	20–40	0.05	3.41	23.61	93.32	39.73	99.38
	40–60	0.04	3.21	26.11	88.48	41.32	98.48
	60–80	0.04	3.47	26.75	95.25	42.53	104.79
	80–100	0.03	3.15	25.55	84.41	40.93	105.75
No.8	0–20	0.17	3.32	21.46	84.70	34.84	105.57
	20–40	0.14	3.39	22.00	76.86	34.68	104.01
	40–60	0.11	3.44	20.51	83.93	37.12	108.17
	60–80	0.09	3.17	18.27	80.19	35.87	104.50
	80–100	0.07	2.74	16.71	82.72	33.25	93.21

(*To be continued on the next page*)

(*Continued*)

No.	Soil depth (cm)	Cd	As	Pb	Cr	Ni	Zn
No.9	0–20	0.08	5.34	35.78	43.29	14.11	74.79
	20–40	0.00	4.87	33.49	41.16	13.85	71.76
	40–60	Not detected	5.20	36.47	44.76	15.87	81.43
	60–80	0.03	5.13	33.16	45.90	16.10	76.05
	80–100	Not detected	5.22	34.26	44.95	15.83	75.48
No.10	0–20	0.08	8.14	28.09	84.52	32.17	107.04
	20–40	0.04	7.71	26.86	84.31	32.03	104.83
	40–60	0.04	8.22	24.86	71.79	31.07	99.24
	60–80	0.04	8.24	26.36	74.79	33.10	102.61
	80–100	0.05	7.55	25.42	85.23	35.33	101.59
No.11	0–20	0.04	3.81	37.83	16.41	5.30	62.94
	20–40	0.01	4.75	35.24	25.23	9.30	60.87
	40–60	0.10	4.90	30.35	37.90	11.99	59.26
	60–80	0.02	6.46	36.60	18.53	5.91	57.07
	80–100	0.03	6.83	39.23	16.95	5.58	60.76
No.12	0–20	0.08	3.67	33.55	16.49	5.75	61.19
	20–40	0.17	5.13	37.08	36.48	11.01	58.40
	40–60	0.13	5.26	36.31	41.90	13.12	65.55
	60–80	0.10	4.82	30.69	36.75	12.44	63.15
	80–100	0.09	4.27	30.88	29.83	10.23	58.01
No.13	0–20	0.04	2.00	48.38	8.94	2.08	88.68
	20–40	0.05	2.13	46.84	9.99	2.90	114.05
	40–60	0.03	2.12	43.65	10.43	2.94	106.28
	60–80	0.06	2.30	45.98	11.15	3.28	113.12
	80–100	0.03	2.23	45.73	11.49	3.43	115.57
No.14	0–20	0.08	2.56	39.86	11.44	3.16	79.44
	20–40	0.06	2.41	40.86	10.37	2.78	71.18
	40–60	0.06	2.21	38.49	7.85	3.12	69.12
	60–80	0.07	1.94	39.33	6.42	2.20	63.52
	80–100	0.09	1.93	38.87	6.79	2.35	68.07
No.15	0–20	0.07	5.09	42.21	28.23	14.02	78.86
	20–40	0.08	5.54	39.51	29.97	13.32	76.64
	40–60	Not detected	6.41	42.80	29.29	18.19	84.52
	60–80	Not detected	6.65	45.35	28.87	19.74	86.68
	80–100	0.05	5.66	45.33	30.05	19.05	84.33
No.16	0–20	0.05	6.64	34.27	43.98	16.36	65.45
	20–40	0.02	7.29	31.34	48.74	18.14	68.23
	40–60	0.03	9.09	35.55	60.22	25.67	86.56
	60–80	0.01	8.78	38.93	47.02	25.01	91.43
	80–100	0.01	3.30	48.30	12.46	5.74	35.60

(*To be continued on the next page*)

(*Continued*)

No.	Soil depth (cm)	Cd	As	Pb	Cr	Ni	Zn
No.17	0–20	0.11	5.47	31.31	44.12	18.13	104.12
	20–40	0.08	5.62	32.32	45.21	20.82	103.41
	40–60	0.09	5.48	33.53	47.73	20.57	104.57
	60–80	0.03	5.58	33.49	44.75	21.48	104.85
	80–100	0.03	6.10	34.99	51.48	21.77	106.55
No.18	0–20	0.16	5.97	18.69	66.57	19.82	36.35
	20–40	0.09	5.68	15.82	66.62	21.72	38.03
	40–60	0.06	6.05	13.83	73.93	22.51	40.00
	60–80	0.08	6.60	13.87	64.90	23.62	37.73
	80–100	0.09	0.31	14.76	69.99	24.22	39.76
LY/T1678—2014	pH<6.5	≤0.3	≤40	≤50	≤120	–	–
GB15618—2018	pH≤5.5	<0.3	<40	<70	<150	<60	<200
Council Directive 86/278/ EEC of 12 June 1986	–	1–3	–	50–300	–	30–75	150–300

4.3 Water Quality Analysis

The case area has developed water system and numerous rivers. Rivers in the territory are divided into Fuhe River system and Ganjiang River system. 10 samples of surface water were sampled in this study, and their distribution was shown in Figure 10. The water samples were tested by the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences. Specific analysis indicators include: pH, aluminum (Al), arsenic (As), boron (B), barium (Ba), cadmium (Cd), chromium (Cr) and other elements.

The results of water samples show (Table 3) that the irrigation water in the case area is

Table 3 Surface water chemical characteristics in the case area (mg/L)

No.	Al	As	B	Ba	Cd	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Zn
No.1	0.000	0.005	0.002	0.001	0.000	0.000	0.001	0.011	0.000	0.002	0.000	0.003	0.004	0.002
No.2	0.000	0.000	0.001	0.002	0.000	0.001	0.001	0.001	0.000	0.001	0.001	0.004	0.009	0.003
No.3	0.000	0.001	0.002	0.005	0.000	0.000	0.001	0.005	0.000	0.001	0.000	0.003	0.000	0.002
No.4	0.000	0.000	0.002	0.001	0.000	0.000	0.002	0.009	0.001	0.002	0.000	0.001	0.000	0.001
No.5	0.000	0.000	0.001	0.005	0.000	0.000	0.001	0.010	0.001	0.002	0.000	0.004	0.003	0.004
No.6	0.000	0.000	0.001	0.007	0.000	0.000	0.003	0.095	0.001	0.002	0.000	0.002	0.003	0.003
No.7	0.000	0.002	0.002	0.016	0.000	0.002	0.000	0.000	0.001	0.002	0.000	0.003	0.000	0.002
No.8	0.000	0.000	0.001	0.017	0.000	0.000	0.002	0.010	0.001	0.003	0.000	0.006	0.000	0.005
No.9	0.000	0.000	0.001	0.006	0.000	0.000	0.001	0.007	0.000	0.002	0.001	0.002	0.000	0.002
No.10	0.000	0.000	0.001	0.004	0.000	0.000	0.001	0.018	0.001	0.002	0.000	0.004	0.000	0.003
LY/T 1678—2014	–	0.05	–	–	0.005	0.1	–	–	–	–	–	0.1	–	–
GB5749—2022	0.2	0.01	1.0	0.7	0.005	0.05	1.0	0.3	0.1	0.07	0.02	0.01	0.01	1.0
OJ L 348, 24.12. 2008 Directive 2008/105/EC	–	–	–	–	0.000,08	–	–	–	–	–	0.02	0.007,2	–	–

acidic. The results of water samples were compared with the requirements for irrigation water in "Environmental general requirements for production area of edible forest product" (LY/T 1678—2014). The concentrations of arsenic (As), cadmium (Cd), chromium (Cr) and lead (Pb) were much lower than the limit values of irrigation water used for edible forest products. The results of water samples were compared with the "Standards for drinking water quality" (GB 5749—2022)[9], and all the test items of water samples were better than the standard for drinking water. In view of the fact that Le'an bamboo shoots are on the protection list of the China-EU Geographical Indications Agreement in 2020, the test results were compared with the EU environmental quality standard for agricultural water[10], and the test results of water samples also met the environmental requirements of European agricultural water. The water quality in the case area is excellent and meets the requirements for bamboo shoot production.

5 Product Characteristics

5.1 Origin and Characteristics of Le'an Bamboo Shoots

According to the records in pre-Qin literature, bamboo shoots were considered a delicacy on the dining table more than three thousand years ago. There are various ways to consume bamboo shoots, which can be cooked into thousands of delicious dishes. During the reign of Emperor Gaozong of the Song Dynasty, Dong, Deyuan, from the Liukeng Dong family in Le'an, served as an official in the capital. Although he had access to many delicious dishes, he still had a strong preference for the bamboo shoots from his hometown. He often asked his family to bring him bamboo shoots from home and presented them to Emperor Gaozong and other high-ranking officials, all of whom loved the bamboo shoots. In the ninth year of the Chongzhen reign of the Ming Dynasty, the great traveler Xu, Xiake arrived in the Gugang Township of Le'an County. He found the area with its overlapping mountains and lush bamboo forests to be very beautiful and was deeply impressed, reluctant to leave. The villagers entertained Xu, Xiake with local bamboo shoots. The tender and delicious bamboo shoots left a lasting impression on him. Therefore, in the "Travel Notes of XU Xiake" it is recorded: In Dengxianqiao Village, "boiled mushrooms and cooked bamboo shoots were served as a meal," "happened to have a local person bringing bamboo shoots back to an ancient tripod," "always used village wine and mountain bamboo shoots as offerings," etc. Since then, Le'an bamboo shoots have become widely known.

With a pyramid-shaped body, "Lean Bamboo Shoots" possess a complete body, mostly hollow in the middle, and its length ranges from 6 cm to 25 cm. Every bamboo shoot has the same size and its color is natural; the fresh of bamboo shoots appears a color of milky white or golden yellow, it tastes fresh and refreshing. With a natural faint scent taste, it has a high edible rate. In Le'an County, there has been a tradition of eating bamboo shoots since ancient times. As early as the reign of Emperor Huizong of the Song Dynasty, Le'an had processing methods for salted bamboo shoots and pressed bamboo shoot dried products. By the Ming and Qing Dynasties, various bamboo shoot processing technologies continued to improve, and workshops for processing bamboo shoots were ubiquitous. Bamboo shoots had become an important product and a staple dish for the people in the mountainous areas. According to relevant test reports: the protein content of Le'an bamboo shoots and their

processed products is 2.38%–2.9%, and the fat content is 0–0.4%. They are rich in various amino acids such as leucine, isoleucine, and lysine. The canned food of bamboo shoots has a yellowish-white color, tender texture, smooth cuts, complete shape, and a relatively uniform appearance. The excellent ecological environment has nurtured high-quality Le'an bamboo shoots. Upon testing, no heavy metal elements such as arsenic, lead, zinc, and cadmium were detected in Le'an bamboo shoots. The processed bamboo shoot products are free from residues of sulfur dioxide, sorbic acid and benzoic acid.

Table 4 Test results of nutritions of Le'an Bamboo Shoots

Testing company	Sampling time	Testing time	Sample name	Sample type	Unit	Protein	Fat (Limit of quantitation)
Centre Testing International (Wuhan) Co., Ltd.	2022.3	2022.3	Grilled bamboo shoots tips	processed product	g/100g	2.75	0.3
			Boiled bamboo shoots	processed product	g/100g	2.55	0.2
Weifang Harrens-HC Inspection & Technology Co., Ltd.	2022.6	2022.6	Small wild bamboo shoots	processed product	g/100g	2.7	0 (0.5)
			Grilled bamboo shoots tips	processed product	g/100g	2.6	0 (0.5)
Institute for Quality & Safety and Standards of Agricultural Products Research, Jiangxi Academy of Agricultural Sciences	2024.1	2024.2	bamboo shoots	Fresh bamboo shoots	%	2.9	–
Anhui Consumer Testing Technology Co., Ltd.	2024.7	2024.8	Winter bamboo shoots	processed product	g/100g	2.38	0.4

5.2 Production Methods of Le'an Bamboo Shoots

The production of Le'an bamboo shoots involves both wild and cultivated methods. The wild method involves two seasons of spring and winter bamboo shoots that grow naturally each year. As for the cultivated method, the process goes as follows.

(1) Site selection: Le'an bamboo is mainly cultivated in the red and yellow forests soil in the southeast mountainous areas of Le'an County. Before planting, it is necessary to clear the forest land, reclaim the land and dig planting holes according to specifications. When planting, the density is 20–35 plants per mu (1 mu equals 0.066,7 ha), with a spacing of 5 m×6 m or 4 m×5 m.

(2) Transplanting method: mostly, the method of bamboo transplanting is used. First of all, healthy and robust mother bamboo should be selected for bamboo planting. During digging, it should be ensured not to damage the connection between the mother bamboo and rhizome roots, protecting the rhizome and the shoots growing on it. After digging, the mother bamboo is retained with 5–7 discs of branches, the tail is cut off, and it is wrapped with straw or matting, with watering to maintain its moisture. Before planting, a layer of topsoil about 10–15 cm thick is placed at the bottom of the planting hole, and the bamboo rhizome is arranged to spread out. The bamboo culm toors is placed in the planting hole, filled with soil that is 3–5 cm higher than the original depth of the mother bamboo, and then compacted. Continue filling the soil to form a steamedbun shaped mound, and sufficient watering should be done after planting.

(3) Production and processing: Le'an bamboo shoots use fresh bamboo shoots from Le'an

County as raw materials. They are processed using traditional methods combined with modern advanced production techniques, going through over 10 steps such as rinsing, pre-cooking, souping, sealing, sterilizing, and packaging. During the production and processing, special attention is paid to maintaining the pure natural fragrance, freshness, and delicious taste. Therefore, during processing, it is necessary to pay special attention to the following points.

First, the bamboo shoots dugged should be complete, no insects, no old stump, no overnight shoots. The acquisition of bamboo shoots to minimize the exposure time, generally bamboo shoots from digging to production and processing, the interval time is controlled within 4 hours to ensure the freshness of bamboo shoots. Second, in the process of processing and production, groundwater from a hundred-meter depth is used for cleaning and soaking the bamboo shoots. Third, Le'an bamboo shoots adopt traditional sterilization technology, and the sterilization time is reduced by 10 minutes compared with other bamboo shoots, which retains the unique natural fragrance and tender taste of Le'an bamboo shoots.

(4) Production management: Le'an bamboo shoots are produced in strict accordance with the "Canned bamboo shoots" (QB/T1406—2014)[11], "Agricultural industry standards of the People's Republic of China: Green food bamboo shoots and bamboo shoots products" (NY/T1048—2012)[12], "Green food: environmental technical conditions of origin" (NY/T391—2000)[13] and other standards.

6 Social Development, Brands, and Culture

According to the statistical data of 2023, the population of Le'an County is about 380,000, among which the urban population is 140,000 and the rural population is 240,000. There are 18 bamboo shoot processing enterprises and 26 new types of agricultural business entities such as cooperatives. In 2023, the total output of the county was 9.959 billion CNY, of which the output of the bamboo shoot processing industry reached 2.8 billion CNY, accounting for 28.12% of the total output of the county. The development of the bamboo shoot industry helps rural residents to become wealthy and increase their income. In 2023, Jiangxi Guangya Food Co., Ltd, Jiangxi Dengxianqiao Food Co., Ltd, and Jiangxi Pengxin Food Co., Ltd drove more than 30,000 households of farmers through various forms such as "company+base+farmers" and "company+farmers professional cooperatives+ farmers", with an average income increase of 12,000–20,000 CNY per household.

In order to promote the healthy development of the Le'an bamboo shoot brand and help bamboo shoot enterprises grow stronger, Le'an County has built the first forest food industry park with bamboo shoots as the core in Jiangxi Province with a high standard, attracting more than 10 local bamboo shoot processing enterprises to settle in. To further enhance the brand influence of "Le'an Bamboo Shoots" and promote the integrated development of the three industries of the bamboo shoot industry, the Le'an County government has held a variety of rich and colorful bamboo shoot cultural activities for three consecutive years, which have become an important platform for Le'an bamboo shoots to display to the world. Among them, the Le'an Bamboo Shoot Cultural Festival has shown the local folk culture from multiple dimensions. The bamboo shoot peeling and eating "biting spring" competitions in the activities not only enrich people's lives but also further promote the bamboo shoot culture.

In addition, in order to promote the development of the Le'an bamboo shoot industry,

Le'an County has formulated the "Le'an County 2022–2025 Bamboo Shoot Industry Development Action Plan" and the "Implementation Plan for Strengthening the 'Le'an Bamboo Shoot' Regional Public Brand and Promoting the High-quality Development of the Bamboo Shoot Industry". A leading group for strengthening the "Le'an Bamboo Shoot" regional public brand and promoting the high-quality development of the bamboo shoot industry has been established, with the county party secretary and county head serving as the group leader and deputy group leader. The special team has conducted multiple surveys on bamboo industry development-related issues, launched a number of measures, and coordinated the implementation of various measures to take effect.

7 Discussion and Conclusion

Le'an County is rich in bamboo forest resources and has excellent water and soil quality. Le'an bamboo shoots are a high-quality geographical product nurtured in this habitat. The case study on the protection and sustainable development of the subtropical mountains ecological environment of Le'an bamboo shoots systematically organizes and analyzes data on the ecological environment and variety quality of the main production areas of Le'an bamboo shoots. This provides scientific data support for the high-quality development of Le'an bamboo shoots and offers a new approach for empowering local economic development with science and technology.

7.1 Bamboo Forest Management

Aiming to establish a high-quality, efficient and sustainably managed bamboo forest resource system, Le'an County stabilizes the existing area of Moso bamboo forests, moderately expands the artificial cultivation of Moso bamboo, and carries out intensive bamboo forest cultivation and low-yield transformation. Le'an County focuses on demonstration tasks such as the construction of bamboo mountain farm roads, irrigation, application of organic fertilizers, and winter pruning and biological control of pests and diseases to comprehensively promote the construction of standardized bamboo forest production bases. In the main bamboo forest production areas of the county, Le'an County builds high-yield and efficient bamboo shoot production demonstration bases, and takes measures such as pruning, loosening soil, fertilizing, and winter covering to improve comprehensively the benefits of bamboo forests.

7.2 Improvement of the Value Chain of the Product

Relying on Le'an Bamboo Shoot Group Co., Ltd., Jiangxi Guangya Food Co., Ltd., Jiangxi Dengxianqiao Food Co., Ltd., Jiangxi Pengxin Food Co., Ltd., and Jiangxi Lezhifeng Health Industry Co., Ltd., Le'an County continuously improves the basic construction and supporting service functions of the bamboo shoot industrial park, actively guides the production factors such as funds, technology, talents, and logistics to gather in the park to help promoting the development of the bamboo shoot industrial park. For enterprises that establish bamboo shoot processing, bamboo shoot professional cooperatives, and bamboo shoot sales markets, Le'an County priority will be given in handling land use, electricity, financing, and certification.

7.3 Product Brand Building and Regulate the Bamboo Shoots Product Market

To strengthen the brand building of Le'an bamboo shoots, Le'an County encourages enterprises to strive for and create brands, increases the promotion of products that have already obtained brand titles for Le'an bamboo shoots, supports production and processing enterprises to carry out organic food and green food certification and to participate in various display and sales fairs recommended by government departments to enhance the brand influence of their products. To promote the publicity and promotion of the "Le'an Bamboo Shoots" brand, Le'an County has organized bamboo shoot enterprises to participate in exhibitions both within and outside the province. Le'an County optimizes product marketing models, integrates the sales and distribution market, scientifically formulates marketing plans, regulates the procurement of bamboo shoot raw materials and the product sales market, encourages enterprises to establish and improve product traceability systems, and includes bamboo shoot processing enterprises, production bases, cooperatives, and other production and operation entities in the agricultural product quality and safety big data intelligent supervision platform for effective supervision.

7.4 S&T Empowers the Bamboo Shoots Industry

Le'an County actively communicates and coordinates with Jiangxi Normal University to establish a provincial bamboo industry science and technology special mission team, providing technical guidance for bamboo shoot processing enterprises in Le'an County. In December 2023, the College of Food Science and Technology at Nanchang University and Le'an County Development Investment Group Co., Ltd. jointly established the Nanchang University Le'an Bamboo Shoot Research and Development Center, and carried out in-depth cooperation on matters such as the development of new Le'an bamboo shoot products. In addition, by leveraging the strengths of all parties and empowering local industrial development with science, the development concept of "Lucid waters and lush mountains are invaluable assets" is actively implemented. In March 2024, the Institute of Geographic Sciences and Natural Resources Research of the Chinese Academy of Sciences, conducted a survey in Le'an County and proposed to take Le'an bamboo shoots as a breakthrough point for case studies on the protection of subtropical mountains ecological environment and sustainable development of Le'an bamboo shoots, and to trace the ecological environment and growth process of Le'an bamboo shoots. In August 2024, an automatic observation station for the habitat of Le'an bamboo shoots (Figure 14) was built at the Nantianzhou Bamboo and Shoot Dual-use Forest Demonstration Base in Le'an County. This observation station is a low-power internet of things perception system. Through this station, real-time image transmission (Figure 15) can be achieved, and it can automatically identify and record various positioning observation parameters such as air temperature, light, relative humidity, air pressure, wind speed, and wind direction.

Author Contributions

Yan, L. Y. and Yu, B. H. designed the study, and wrote data paper; Yu, L. contributed to collect and organize product data, and wrote data paper; Ai, Z. F., Zheng, J., Wu, J. G., Ouyang, J. and Li, R. G. were responsible for the supervision; Meng, S. W. completed case study and the sampling; Wang, H., Chen, G. H., Chen, G. H., Yuan, C. M., Wang, G. C. and Zheng, X. G. provided the information of enterprises and products.

Figure 14 The automatic observation station of Le'an bamboo shoots was completed in August 2024

Figure 15 Real-time landscape images observed by the automatic observation station of Le'an bamboo shoots in August 2024

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Conflicts of Interest

The authors declare no conflicts of interest.

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