Journal of Global Change Data & Discovery. 2023, 7(2): 158-171
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# GIS Case Study on Lipu Taro-Rice Rotation permanent Farmland

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**Abstract:** Lipu taro-rice rotation is one of known applied cropping system for eco-environmental protection and sustainable development in Xiuren town, Lipu county, Guangxi. The study region is located in the Pearl River Basin's Xijiang water system, characterized by subtropical humid environment with plentiful heat and precipitation. The farm land is primarily consisted of loam and sandy loam, rich in organic matter, productive, and free of pollution; water conservation is promoted. Water quality for irrigation is above the third category standard. Lipu taro is a well-known variety of geographical indication with the highest quality in all taro varieties. This case proposes a new paradigm of eco-environment protection and sustainable development for Lipu taro plantation. We also design a high quality developing path to the taro commercial brand. The dataset is composed of five sessions including (i) the geographical range, (ii) physical and climatological properties of the taro-rice rotation case, (iii) quality characteristics of Lipu taro, (iv) management and historical culture. The data formats are .shp, .kmz, tif, .xlsx, .txt, .docx, .jpg with a size of 140 MB.

**Keywords: Lipu taro; geographical indication; GIES: case 17**

**DOI:** https://doi.org/10.3974/geodp.2023.02.04

**CSTR:** https://cstr.escience.org.cn/CSTR:20146.14.2023.02.04

**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.2023.06.02.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2023.06.02.V1.

**Received:** 12-03-2023; **Accepted:** 20-06-2023; **Published:** 25-06-2023

**Foundations:** Chinese Academy of Sciences-Local Government Academic Cooperation Project; Ministry of Science and Technology of P. R. China (2022YFF0801804)

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**Data Citation:** [1] Mo, X. G., Sun, Z. W., Zhou, X. M., *et al*. GIS case study on Lipu taro-rice rotation permanent farmland [J]. *Journal of Global Change Data & Discovery*, 2023, 7(2): 158–171. https://doi.org/10.3974/geodp.2023.02.04. https://cstr.escience.org.cn/CSTR:20146.14.2023.02.04.

[2] Mo, X. G., Sun, Z. W., Zhou, X. M., *et al*. Dataset of Lipu taro-rice rotation permanent farmland case dataset on ecosystem protection and sustainable development [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2023. https://doi.org/10.3974/geodb.2023.06.02.V1. https://cstr.escience.org.cn/CSTR:20146.11.2023.06.02.V1.

## 1 Introduction

With the improvement of living standards, consumers' demand for high-quality agricultural products is increasing. With the advantages of geographical and natural environment, indicated agricultural products of specific regions have gradually become symbols with great potentially commercial worth, and are attractive to consumers. Detection of the background status of the natural environment, the dynamic monitoring of the crop growth and processing of agricultural products are important to guarantee the high quality and pollution-free products and subsequent processed food. Currently, under the support of geographic information and internet technology, tracing the source of high-quality agricultural products is a general way to improve the reputation and commercial potential worth of agricultural products and maintain sustainable development.

China is a significant producer of taro over the world, with annual output of about 2 million tons. In 2020, the total export of taro was 68,746 ton[1].

Taro is an *Araceae* plant, commonly called as "Kuiyu", "Qingyu", "Tuzhi", "Maoyu". The typical varieties are multi-headed taro, great taro, and taro with cormels, which is commonly seen tuber crop and widely cultivated in the tropical areas. Taro is originated from India continent. In China, most varieties of taros are cultivated in Pearl River basin, Taiwan Island, Yangtze River basin and other provinces. The tubers of taro crop are rich in starch, protein, dietary fiber, vitamins, minerals, etc. It tastes soft, sweet, and waxy. It has a similar nutritional value to potatoes, but it doesn't contain solanine. Except as dietary food, it is also taken as medicinal materials. Generally, taro plays an irreplaceable role in food security and diversity. Additionally, taro has specific therapeutic and medical functions, such as antihypertensive effect, postponing senility, and enhancing the body's immunity. It is a healthy food for daily life[2, 3].

Lipu is a county-level city, under the administration of Guilin municipality in Guangxi autonomous region, China. It is situated in the northeast of Guangxi and south of Guilin. It belongs to subtropical zone which is warm and wet in the four seasons. The especial climate and natural geographical environment have evolved the localized variety of great taro known as Lipu taro. Lipu taro is large in size, high in starch content. It is also rich in abundance amino acids and trace elements that can effectively improve body's immunity. The cooked lipu taro is soft, glutinous and fragrant. Lipu taro is called "the best of taro" and selected as a royal tribute in the Qing dynasty. At the beginning of the 21th century, the TV drama "Prime Minister Liu Luoguo" has revealed the profound historical and cultural deposits and modern taste of Lipu taro. With the strong support of local administration and the positive response from farmers, the planting scale of Lipu taro has been considerably expanded in Lipu and nearby counties. At present, the planting size of Lipu taro in Lipu exceeds 40,000 mu ($\approx$ 2,666.7 ha), with annual income of more than 600 million Yuan. In terms of planting size and manufacture techniques of Lipu taro, Lipu is the largest production, manufacture and export base of taro.

During plant growth and development, Lipu taro requires sufficient nutrients and water supplies. Relevant studies suggest that continuous cultivation usually leads to deterioration of soil physical and chemical properties, deficiency and imbalance of nutrient elements, alienation of rhizosphere microbial population structure, and aggravation of soil-borne diseases[4]. Rotation of taro–paddy rice is suggested to overcome these adverse effects.

This paper sorts out and collects the farmland's ecological and environmental information on Lipu taro production in Xiuren town, Lipu county. And further, the roadmap of expanding the commercial value of Lipu taro is raised.

## 2 Metadata of the Dataset

The metadata of the Dataset of Lipu taro-rice rotation permanent farmland case dataset on ecosystem protection and sustainable development[5] 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 Lipu taro-rice rotation permanent farmland case

| Items | Description |
|---|---|
| Dataset full name | Dataset of Lipu taro-rice rotation permanent farmland case dataset on ecosystem protection and sustainable development |
| Dataset short name | LipuTaroRiceCase17 |
| Authors | Mo, X. G. 0000-0003-3830-6083, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, moxg@igsnrr.ac.cn<br>Sun, Z. W., Lipu government administration, 1026622152@qq.com<br>Zhou, X. M., Lipu government administration, 534308487@qq.com<br>Mo, Y. W., Bureau of Agriculture and Rural Affairs of Lipu, lpsnyncj@guilin.gov.cn<br>Qiu, Z. Y., Lipu agriculture and rural bureau, 32168285@qq.com<br>Li, Z. B., Lipu Meteorological Bureau, lpqx121@163.com<br>Qi, D. X., Lipu bureau of agricultural soil fertilizer station, lptfz4806@163.com<br>Liu, X. M., Lipu ecological Environment Bureau, 1259919292@qq.com<br>Zhuo, L. X., Lijiang Cultural Tourism Investment Co., 35943942@qq.com<br>Su, Y., Guangxi Guipin Cloud Information Technology Co. LTD, y9336005189@126.com<br>Xiong, H. M., Guangxi Guipin Cloud Information Technology Co. LTD, y9336005189@126.com<br>Liu, S. X., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, liusx@igsnrr.ac.cn<br>Hu, S., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, hus.08b@igsnrr.ac.cn<br>Nsigayehe, J. M. V., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, microphone49@yahoo.com<br>Liu, X. Y., Institute of Geographic Sciences and Natural Resources Research，Chinese Academy of Sciences, liuxy.20b@igsnrr.ac.cn<br>Zhou, H. W., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, zhouhw.18b@igsnrr.ac.c |
| Geographic area | Xiuren township, Lipu county, Guilin city, Guangxi autonomous region |
| Data format | .shp, .xlsx, .docx |
| Data size | 140 MB |
| Data files | Four sub-dataset: (1) boundary data of the case area; (2) physical geographical conditions (including climate, hydrology, soil, etc.); (3) quality characteristics of Lipu taro; (4) management and historical culture data |
| Data publisher | Global Change Scientific Research Data Publishing System 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[6] |
| Communication and searchable system | DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS |

## 3 Description of the Lipu Taro-Rice Rotation Study Case

### 3.1 Geographic Data

**3.1.1** Brief Introduction of Lipu County and Xiuren Township

Lipu is located between 110°06′E–110°41′E and 24°18′N–24°46′N. It belongs to a low to medium mountainous area with Karst landform. The area of Lipu is 1,758.62 km$^2$ with a population of 385,000, administratively subdivided into 13 townships.

Xiuren is one of the three major towns in Lipu county, located in the southwest of Lipu, with a long history. In the first year of Wu Ganlu of the Three Kingdoms (265 AD), Jianling county was set up in Wu dynasty. In the third year of Changqing of the Tang dynasty (823 AD), the name of Jianling was changed to Xiuren. In the first year of Yuanfeng of the Song Dynasty (1078 AD), Xiuren county was set again. In August, 1951, Xiuren county was cancelled and merged with Lipu county. Xiuren covers an area of 109 km$^2$, where forest coverage is more than 80%. There are 44.81 ha of farmland, including 32 ha of paddy fields and 132.75 ha of dry land. The population of Xiuren town is 35,300[7]. The town is famous for cultivation of Lipu taro, water chestnut and small tangerine. After years of comprehensive development, the town has gradually become a mass cultivation and manufacture base of agricultural products.

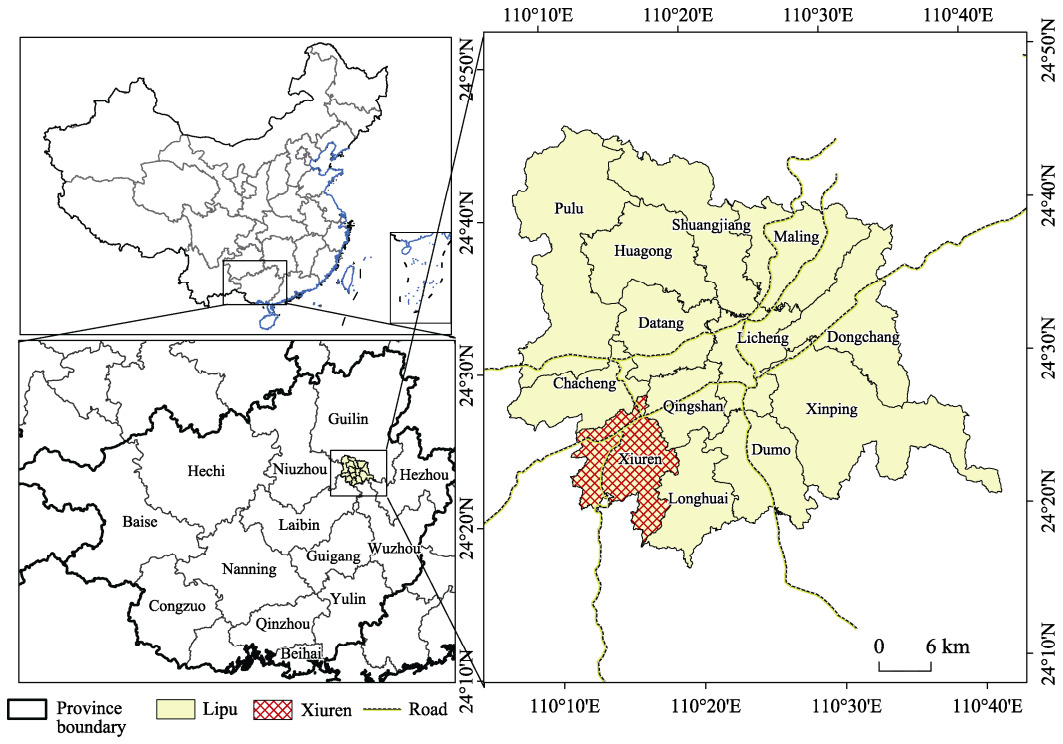


**Figure 1** Map of geo-location and extents of Lipu and Xiuren town

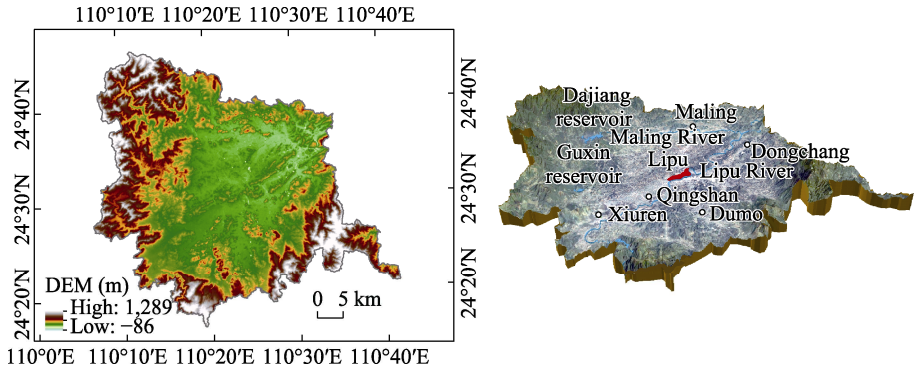


**Figure 2** Elevation and 3D topographic of Lipu

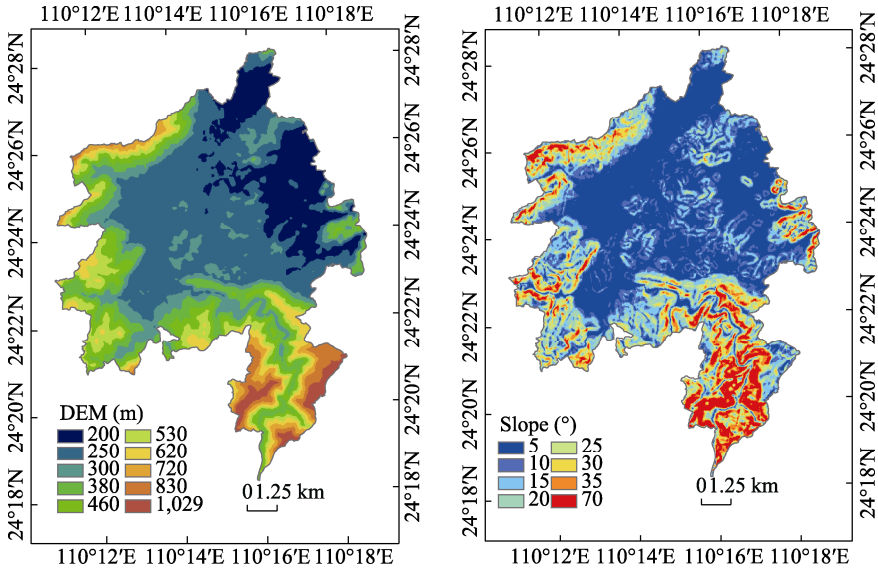


**Figure 3** Topography and slope of Xiuren town

### **3.1.2** Meteorological Characteristics

Lipu country is located in the north side of the Tropic of Cancer. It belongs to the north subtropical humid climate zone, which is warm in winter and hot in summer, and abundant in precipitation. The mean annual temperature is 19.8 °C, with 28.4±0.9 °C in July and 9.5±1.6 °C in January. The mean annual accumulated temperature is 7,181.5 °C (From Lipu County Annals), and the active accumulated temperature (≥10 °C) is 3,454 °C (Σ (T–10)). The temperature in the low plain area is slightly higher than the around mountainous zones. The mean annual sunshine duration is 1,536.6 hours, and the mean annual solar radiation is 4,021.58 MJ $m^{-2}$. The frost-free period is more than 310 days, in which the number of days with temperature ≥10 °C is about 290 days. The mean annual precipitation is 1,397 mm, and the rainfall is concentrated in summer monsoon period (from April to August), accounting for 68.3% of the annual rainfall. On average, there is one light rain in each two days, one moderate rain in each nine days, and one heavy rain in each 25 days. The annual mean relative humidity is 79%. The annual mean reference crop evapotranspiration is 930 mm, and the drought mainly occurs in autumn. With the impact of global climate change, the frequencies of extreme weather and climate events such as extreme drought and continuous heavy rainfall are increasing. The extremes may result in serious damage and loss.

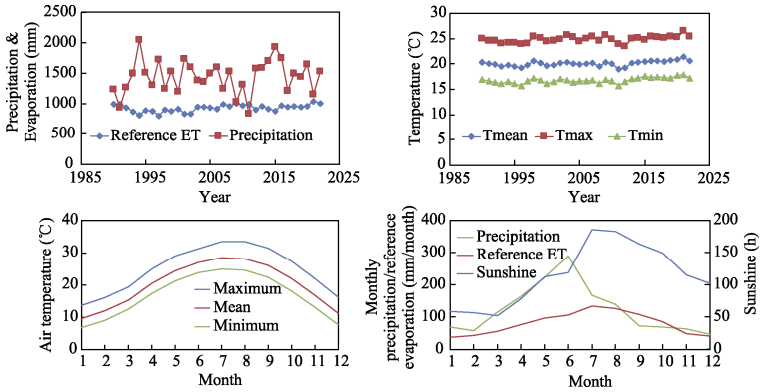


**Figure 4** Climatologic characteristics of Lipu

### **3.1.3** Ecological Environment and Cultivated Land Status

The forest resources of Lipu destroyed seriously in the 1960s. In the 1980s, mountains were closed for forest conservation. By the end of the 1990s, the woody land area of Lipu had recovered to 65,200 ha, which was close to early 1950s. At the end of 1990s, the county's forest coverage reached 66.9%. According to MODIS remote sensing data from 2000 to 2018, the vegetation greenness in Lipu was recovered greatly, in which 69.5% of the area is significantly improved[8], indicating that the overall conditions of the natural eco-environment have remarkably improved. For example, according to land use identified by Sentinel 2 in 2020, the land use/cover types are forest (64.21%), grassland (19.32%) and paddy field (8.49%) in Xiuren town.

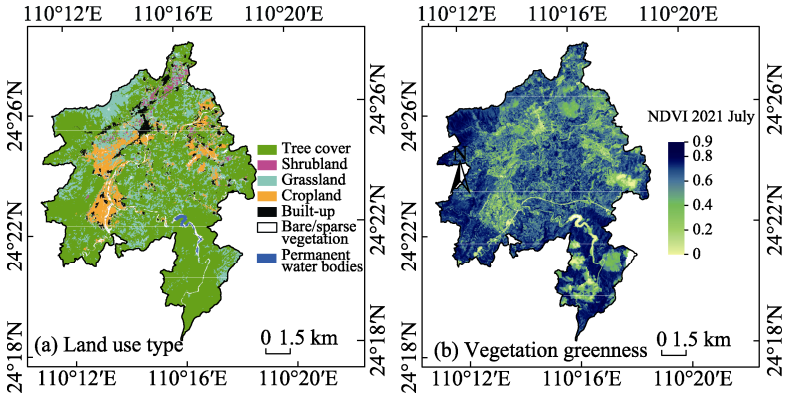


**Figure 5** Maps of Land use and vegetation greenness in July in Xiuren town

Lipu is dominated by forest and cultivated land, among which forest is mainly distributed in the mountain zone and farmland in the plain and hilly zones in the west and northeast (Figure 2). The total land size of Lipu county is 1,759.7 km$^2$ with farmland of 16,249.34 ha, accounting for 9.22% of the total land area[7]. Among them, the irrigated paddy field is 14,080.37 ha, accounting for 66.59% of the farmland.

The soil texture of cultivated land in Lipu is dominated by sandy loam and loam, accounting for 48.36% and 38.72% of the total farmland respectively. Clay loam and clay soil types account for 9.18% and 3.74%, respectively[9]. In Xiuren town, loam and sandy loam accounted for 52.43% and 41.38%, respectively. The pH values of the cultivated soil range from 3.38 to 7.75.

According to the guidance of "Classification of cultivated land fertility in national cultivated land type areas" (NY/1309—1996), the cultivated land fertility of Lipu was categorized. The results show that the high-yield cultivated lands (level 1 and 2) account for 18.27% of the total farmland; the middle-class farmlands (level 3 and level 4) account for 41.66%; the low-yield cultivated lands (level 5 and 6) account for 40.07%. In Xiuren, the high-, middle- and low-yield farmlands account for 27.81%, 44.87% and 27.31%, respectively.

Statistics on the main nutrient status of Lipu farmland show that the average concentrations of soil organic matter, total nitrogen, available phosphorus, available potassium, available zinc, and available boron are 26–32.1 g/kg, 1.68–2.15 g/kg, 24.9–40.4 mg/kg, 62–100 mg/kg, 1.16–1.43 mg/kg, 0.40–0.46 mg/kg, respectively[9]. The spatial patterns of soil organic matter and total nitrogen contents are highly consistent.

The farmland in Xiuren is slightly acidic, with an average pH of 5.34±1.23. The average organic matter content was 35.55±14.42 g/kg, in which the proportion of 40 g/kg, 30–40 g/kg, 20–30 g/kg and 10–20 g/kg are 19.16%, 40.17%, 38.89% and 1.78%, respectively. The average total nitrogen content was 1.99±0.81 g/kg, in which the proportions of 2.5 g/kg, 1.5–2.5 g/kg, 1–1.5 g/kg and 0.75–1.0 g/kg are 13.37%, 62.05%, 24.23% and 0.35%, respectively.

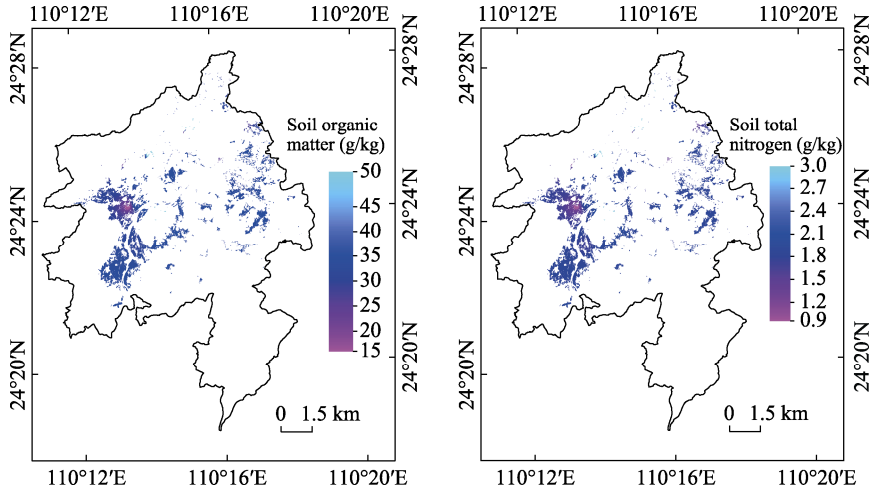


**Figure 6** Soil organic matter content and total nitrogen content in the cultivated land of Xiuren town

Soil heavy metals mainly included selenium (Se), mercury (Hg), arsenic (As), lead (Pb), cadmium (Cd) and chromium (Cr). The contents of Cr, Pb, As, Se, Hg, and Cd from high to low are 23–85 mg/kg, 10.3–33.9 mg/kg, 1.96–14.5 mg/kg, 0.13–0.57 mg/kg 0.071–0.492 mg/kg, and 0.08–0.37 mg/kg, respectively. All is much lower than the threshold of soil heavy metal pollution in the "Standard for Soil Environmental Quality" (GB 15618—2018)[10]. The concentrations of mercury, lead, cadmium, chromium and arsenic in the soil of the Lipu taro-rice rotation fields in Xiuren (Table 2) and the results of sampling (geo-location: 110°13′32″E, 24°24′11″N) and tested by the project team in January 2023 (Table 3) were much lower than the screening values of soil pollution risk for agricultural land referred to the soil environmental quality standard (GB 15618—2018)[10].

**Table 2** Soil heavy metal contents monitored in the case area

| Test items | Unit | Method of detection | Results | Limit value |
|---|---|---|---|---|
| Cd | mg/kg | GB/T 17141—1997 | 0.075 | ≤0.4 |
| Pd | mg/kg | GB/T 17141—1997 | 19.3 | ≤100 |
| Hg | mg/kg | GB/T 22105.1—2008 | 0.0719 | ≤0.5 |
| As | mg/kg | GB/T 22105.2—2008 | 7.73 | ≤30 |
| Cr | mg/kg | HJ 491—2019 | 91 | ≤250 |

**Table 3** Soil heavy metal contents in the Lipu taro-rice rotation experimental field in Darong village, Xiuren town (Unit: mg/kg)

| Sites | Crop | As | Cd | Pb | Ti | Cr | Mn | Fe | Ni | Cu | Zn | Sr | Zr | Mo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Taro | 7.00 | 0.12 | 29.10 | 5,005.89 | 67.35 | 116.81 | 29,356.34 | 27.36 | 68.57 | 81.42 | 71.43 | 477.88 | 0.62 |
| 2 | Taro | 7.13 | 0.13 | 28.07 | 5,002.58 | 70.26 | 157.51 | 30,914.00 | 29.14 | 67.48 | 80.87 | 70.76 | 499.11 | 0.53 |
| 3 | Taro | 5.75 | 0.15 | 24.37 | 4,505.25 | 59.52 | 226.76 | 26,709.16 | 22.98 | 59.77 | 71.27 | 57.82 | 593.97 | 0.58 |
| 4 | Taro | 8.26 | 0.12 | 28.88 | 5,187.10 | 71.83 | 368.06 | 37,869.58 | 31.68 | 68.60 | 84.59 | 78.51 | 409.45 | 0.65 |
| 5 | Taro | 11.20 | 0.20 | 32.26 | 5,701.44 | 78.60 | 401.02 | 36,298.44 | 35.21 | 72.01 | 101.76 | 82.30 | 474.22 | 0.96 |
| 6 | Rice | 9.22 | 0.13 | 31.67 | 5,577.48 | 73.90 | 369.55 | 39,927.58 | 33.73 | 75.49 | 93.34 | 84.62 | 474.32 | 0.65 |
| 7 | Rice | 7.40 | 0.12 | 28.93 | 5,275.33 | 73.89 | 273.20 | 33,634.14 | 29.92 | 124.97 | 87.69 | 78.17 | 463.58 | 0.57 |
| 8 | Rice | 6.87 | 0.10 | 29.37 | 5,086.97 | 83.92 | 282.68 | 30,954.66 | 30.26 | 74.76 | 87.11 | 80.21 | 467.67 | 0.62 |
| 9 | Rice | 6.78 | 0.16 | 30.44 | 5,445.77 | 75.24 | 187.89 | 27,200.60 | 31.62 | 78.14 | 92.67 | 80.42 | 525.86 | 0.56 |

### **3.1.4** Water Quantity and Quality

Lipu district belongs to the Xijiang basin, a branch of Pearl River. There are eleven catchments whose drainage areas are more than 50 $km^2$. The main channel is the Lipu River. The groundwater in the region is mainly from springs and underground rivers. According to the "Groundwater investigation report of Guangxi Zhuang autonomous region", the groundwater storage in Lipu district is $16.5\times10^4$ $m^3/km^2$, or 290 million $m^3$, and the daily dischargeable amount is $80\times10^4$ $m^3$. The river discharge in the domain is supplied by rainfall, with annual runoff depth of 948.7 mm and annual runoff volume of 1.682,9 billion $m^3$. The total groundwater volume is 290.45 million $m^3$[11]. There are 376 water reservoir projects with capacity of 155.42 million $m^3$, including 45 reservoirs, 21 water diversion canals, and 273 water ponds. The water quality data of irrigation canals of Darong village in Xiuren town (geo-location of sampling: 110°13′15″E, 24°24′13″N) showed that the contents of 26 chemical elements (such as aluminum, arsenic, boron of ions, etc.) are lower than the urban drinking water supply standards (Table 4). Overall, Lipu has abundant water resources with high water quality and operating water conservancy facilities.

## 3.2 Characteristics of Lipu Taro

### **3.2.1** Origin and Characteristics of Lipu Taro

Taro (*Colocasia esculenta*) belongs to a kind of perennial herbaceous plant of *Araceae* and is generally cultivated as an annual crop. Taro is native to tropical and humid regions such as China, India, and Malaysia[12], and is cultivated worldwide. China's taro is mainly distributed in the Pearl River, Yangtze River, and Huaihe River basins[13].

Lipu taro belongs to Kui (meaning "large") taro, which originally stemmed from wild taro. It is an extraordinary variety formed after a long period of natural selection and artificial breeding. The cultivating history has lasted for 600 years in Lipu. Affected by the local climate and environment, the corm of Lipu taro is evolved in an oval-shape, which looks like a spindle and weighs about 0.5–1.5 kg. The skin of corm is rough and brown. As the

**Table 4** Statistics of water quality data in the case area of Xiuren town

| Test element | Banyan village water channel | Unit | Urban drinking water supply standards | Test element | Banyan village water channel | Unit | Urban drinking water supply standards |
|---|---|---|---|---|---|---|---|
| Al | 0.09 | mg/L | 0.2 | Sb | 0.207 | ug/L | 5 |
| B | 0.06 | mg/L | 0.5 | Se | 0.486 | ug/L | 10 |
| Fe | 0.08 | mg/L | 0.3 | Zn | 0.212 | ug/L | 1,000 |
| Na | 0.94 | mg/L | 200 | Mo | 0.367 | ug/L | 70 |
| $SO_4^{2-}$ | 8.09 | mg/L | 250 | Li | Undetected | mg/L | – |
| As | 0.526 | ug/L | 10 | Ca | 18.86 | mg/L | – |
| Ba | 98.304 | ug/L | 700 | K | 0.92 | mg/L | – |
| Cd | 0.002 | ug/L | 3 | Mg | 4.60 | mg/L | – |
| Cr | 3.030 | ug/L | 50 | P | Undetected | mg/L | – |
| Cu | 1.946 | ug/L | 1,000 | Sr | 0.039 | mg/L | – |
| Mn | 1.659 | ug/L | 100 | $SiO_2$ | 4.50 | mg/L | – |
| Ni | 0.372 | ug/L | 20 | Co | 0.063 | ug/L | – |
| Pb | 0.073 | ug/L | 10 | Sn | 0.009 | ug/L | – |

betel nut pattern is obviously seen in the cross section of corm, it is also called Betel Nut Taro. While cooked, Lipu taro releases a special fragrant flavor and tastes crisp, powdery, glutinous, sweet, soft, and fresh. Due to its rich nutrition, soft meat, and fragrant taste, Lipu taro is praised as "the king of taros". According to the "Lipu Chronicle" of 1953, it wrote: "Old chronicle writing: There was ever a taro weighing 5 kg, but there is no such big one today. And the best taros are those cultivated in front of the Guandi Temple outside the town." In Lipu, taro is planted widely, and the current planting area has risen up to more than 40,000 mu (≈59.97 ha). Among them, Xiuren is the main base of high-quality Lipu taro plantation.

**Figure 7** Photos of Lipu taro crop harvesting site (left) and taro roots (right)

### **3.2.2** Quality of Lipu Taro

The quality analysis of Lipu taro reveals that the total sugar content of Lipu taro is higher than 1.5 g/100 g, the starch content is 25.7 g/100 g, and the content of amylopectin is higher than 82.5% (Table 5), which makes the Lipu taro taste as "sweet and glutinous". Lipu taro is also rich in protein with more than 20 kinds of amino acids. It is also rich in trace elements such as zinc, iron, potassium, and selenium which are necessary for human immunity.

Soil quality for Lipu taro planting in Xiuren town meets the requirements of green production. Tests of heavy metal and pesticide residues in the taro products showed that the residues concentrations of lead and cadmium are less than 0.05 mg/kg, and the residues contents of chlorpyrifos and trichlorfon are lower than 0.005 mg/kg, which is far less than the risk threshold of heavy metals and pesticide residues stipulated in China food safety standards (GB 2762—2017, GB 2763—2021) (Table 6).

**Table 5** Quality data of Lipu Taro

| Test items | Content | Test items | Content |
|---|---|---|---|
| Content of water (%) | 65.9 | Fe (mg/kg) | 1.2 |
| Content of ash (%) | 1.0 | K (mg/100g) | 448 |
| Protein (g/100g) | 1.88 | Sn (mg/kg)） | 0.0096 |
| Starch (g/100g) | 25.7 | Total amino acids (%) | 1.38 |
| Zn (mg/kg) | 19.8 | | |

**Table 6** List of heavy metal and pesticide residue

| Test items | Content | Standard value |
|---|---|---|
| Pb (mg/kg) | <0.02 | ≤0.2 |
| Cd (mg/kg) | 0.05 | ≤0.1 |
| Chlorpyrifos (mg/kg) | <0.005 | ≤0.02 |
| Trichlorfon (mg/kg) | <0.005 | ≤0.2 |

### 3.3 Lipu Taro Industry

As a high-quality taro brand in China, Lipu taro is cultivated in unique geographical environment and has a long with plentifully historical and cultural heritage. The planting size and manufacture techniques of Lipu taro rank firstly in China. At present, a whole manufacture catenary has been developed, which includes the protection of variety resources, foster of healthy seedlings, cultivation, food manufacture, marketing and exportation.

**Cooperative enterprise 1: Lipu Lijiang Cultural Tourism Investment Co., Ltd.**

Lijiang Culture and Tourism Investment Co., LTD. (abbreviation: Cultural Tourism Investment), is a wholly state-owned enterprise specializing in development of culture and tourism, which mainly focuses on optimization and integration of culture and tourism resources, integration and development of culture and tourism, as well as expansion and design of culture and tourism projects. The company fully improves the brand influence of "Lipu taro" by promoting the deep integration of tourism and primary, secondary and tertiary industries, and by building a livable and tourist-friendly tourism to achieve favourable economic, ecological and social benefits.

**Cooperative enterprise 2: Guangxi Guipinyun Information Technology Co., Ltd.**

The "Guipinyun" e-commerce platform built by Guangxi Guipinyun Information Technology Co., Ltd., is committed to serving high-quality small and medium-sized enterprises and outstanding entrepreneurs in Guangxi, focused on advertising and selling Guangxi characteristic agricultural and sideline products, industrial products and cultural and tourism products with green water, green mountains, ecological beauty, health and longevity. It provides enterprises and entrepreneurs of Guangxi with targeted product sales, brand packaging upgrades, cloud warehouse sharing logistics and other online and offline one-stop comprehensive services.

**3.3.1** Cultivation Management of Lipu Taro

The cultivation and field management schedule of Lipu taro is based on the "Light and simple cultivation technology of Lipu taro—paddy field". The use of fertilizer and pesticide in Lipu Taro field followed "Green food—fertilizer application guideline (NY/T 394)", "Green food—guideline for application of pesticide (GB/T 8321)", "Foliar fertilizer with organic matter (GB/T 17419)", "Foliar trace element fertilizer (GB/T 17420)", "Microbial fertilizers (NY/T 227)", "Code of practice for production techniques of pollution-free taro

(NY 5015)", and "Cultivation technical practice for pollution-free agricultural product in whole growth period: Part 4 (NY/T 2798.4—2015)". The field management includes the following steps[14]:

(1) Soil tilth preparation and fertilization

Well-drained farmland with well water and fertilizer retention ability is favourable for taro plantation. Before ploughing, 500 kg organic fertilizer, 100 kg slow-release long-effect compound fertilizer (18-8-26 of N-P-K), 60 kg calcium magnesium phosphate, 30 kg potassium sulfate, and 40 kg medium and trace element fertilizer are mixed well and applied per 667 $m^2$ area at one time. The land is divided into several plots. The distance of each two plots ranges from 0.8 to 1.0 m, the height and width of each plot ranged from 40 to 45 cm and 1.0 to 1.2 m, respectively. Each plot can hold two rows of taro.

(2) Seeding and germination

Rhizome is the stock part of taro in production. The tissue culture seedlings used for 667 $km^2$ is about 100 kg. After soaked in 50% carbendazim diluted 600 times for 30 minutes, the tissue culture seedlings then evenly placed in the seedbed, and covered by fine sand of 3 cm. After the seedbed is wetted, it should be covered with plastic film. When the buds of tissue culture seedlings are 1–2 cm in length, the seedlings should be transplanted into the field.

(3) Planting time and density

From mid-February to early March, taro should be transplanted into the field when the air temperature is above 15 °C. The planting density is about 2,000 to 2,200 plants per 667 $km^2$. The taro is transplanted with its buds tipped down at about 30° tilt. The planted depth is ranged from 15 to 20 cm, and the spacing between the two plants is 30 cm. Silver-gray plastic film was mulched after transplanting. When the plastic film was lifted up by the bud, hole broken should be taken in time.

(4) Field management

The field management of Lipu taro includes the following steps: water management, lateral bud and over growth control, pest control, and harvesting.

**Water management:** Lipu taro requires plenty water throughout the growing season. From March to April, it is rainy frequently and the soil can keep the required moisture without irrigation. From May to August, the taro is in the flourishing stage. To guarantee the taro healthy growth and avoid drought-induced leaf senescence, water in the furrows should be maintained by a depth of 7 to 8 cm. The critical period for taro growth is from September to November, when the corm grows quickly. Shallow water should be maintained in the furrow to meet water demand.

**Lateral buds and over growth control:** When leaves increase to 7–8 pieces, lateral buds appear and should be removed as early as possible to reduce the nutrient consumption. In the flourishing stage, if the taro is over growth, 15% paclobutrazol can be irrigated, the plant height is generally controlled to 1.0–1.3 m. Generally, 0.2–0.3 kg of 15% paclobutrazol should be mixed with 500 kg water per 667 ha.

**Pest control**: The main diseases of Lipu taro are taro blight and soft rot. Commonly used pesticide for taro blight include: 25% metalaxyl diluted 800 times, 80% dimethomorph diluted by 1,000 times, silver fare (6.25% fluopyram + 22.5% propamocarb hydrochloride) diluted 1,000 times, 10% fluothiazolpiethyl ketone diluted 2,000 times. In practice, the above pesticide can be combined used with speader (such as organic silicon, and neutral washing powder), the pesticide used every 10 to 15 days during the whole period of the disease. Caustic lime and tea bran can kill the pest in the soil and prevent the soft rot. Normally, 70 to 100 kg of caustic lime and 50 kg of tea bran was applied per 667 $km^2$ before transplanting. When the soft rot is found from June to August, the roots can be irrigated with 20% zinc thiazole suspension diluted by 500 times. The main insect of taro is prodenia litura,

which could be controlled by 5% chlorfluazuron diluted by 1,000 times or 0.5% emamectin benzoate diluted by 1,000 times. The pesticide should be sprayed every 7 to 10 days and used 2–3 times during the disease cycle.

(5) Harvesting

Generally, Lipu taro may be harvested in November or postpone to December before frost forming.

**3.3.2** Industrialized Operation of Cropping and Management

Lipu taro has been cultivated in large cropland and the output of taro has become one of the pillar industries and important income of Lipu city. In 2020, the annual planting area of Lipu taro was 3,455 ha and Xiuren town was 700 ha. The yield of taro has reached 30 t/ha, and the total yield of taro has reached 100,000 tons in Lipu. In order to ensure the integrity of the industrial chain for Lipu taro, easy and simple cultivation techniques has been applied in large planting areas and the complete industrial chain has been formed. Some projects, such as the Guangxi autonomous region science and technology program "Application and demonstration of integrated technologies in the full industry chain of Lipu taro (2020)", have been promoting the establishment of green-food production base and selenium enrichment of Lipu taro. Besides improvement of the taro quality, the local administration also promotes commodity cultivation and commercialization of taro manufactures.

Commodity cultivation: The pattern of commodity cultivation of Lipu taro has been preliminarily formed in the county, with 35 green Lipu taro cultivation bases, each covering an area over 3.335 ha.

Light and simply cultivation technology: In cooperation with Biotechnology Research Institute, Guangxi Academy of Agricultural Sciences, the Lipu Agriculture and Rural Bureau adopted tissue culture and mutation technology to select the new varieties "Guiyu 2" and "Guiyu 1", used easy and simple cultivation techniques featured as "Formula fertilization, high plots mulching and soil added-free, Pollution-free pest control"

Industrial catenary: The whole industrial catenary has been formed. It includes variety resources protection → healthy seedlings culture → commodity taro planting → manufacture → transportation → storage → sales. The Lipu taro can now be supplied year round.

### 3.4 Industrialization of Lipu Taro

The earliest written record of Lipu cultivation is the Lipu Chronicle in the third year of the Republic of China, which is only located in the area of Guandi Temple and its surrounding area. In 1963, the cultivation area was 47 ha, and the export amount was only 225 tons. In the 1960s and 1970s, the cultivation area was about 66.7 ha, and the export amount was hundreds of tons. Until the 1990s, along with the performance of TV series "Prime Minister Liu Luoguo", the price of taro on the market skyrocketed. In 1996, the administration of Lipu county took great steps to develop Lipu taro by appointed the Agricultural Bureau to establish Lipu Taro Development Co., LTD, and established the Lipu County Famous and Excellent Agricultural Products Association. Since then brand of Lipu taro has been issued and won a series of honors (Table 7).

With the passage of time, the taro cultivation technology has also undergone a qualitative leap. Before the 1970s, it was basically planted by the production brigade, supplied only farmyard manure, 800–1,000 plants/667 $m^2$, single row, and the harvest yield was about 10–12 t/ha. The first technological leap in taro cultivation occurred in 1988, paclobulozole was used for taro cultivation. By controlling the height of taro canopy and increasing the planting density to 2,000 plants/667 $m^2$, the yield increased to more than 15 t/ha.

**Table 7** Honor list of Lipu taro

| Time | Accolades |
|---|---|
| 2000 | Trademark of certificate of origin |
| 2000 | Certificate trademark of national geographical indication |
| 2004 | Pollution-free origin product certification |
| 2005 | Geographical indication products by the State Administration of Quality Supervision |
| 2015 | Agricultural products geographical indication by Ministry of Agriculture |
| 2017 | Mark of China's famous and special new agricultural products |
| 2017 | Lipu taro as a regional brand worth 1.068 billion RMB evaluated by the General Administration of Quality Supervision, Inspection and Quarantine and China Quality Certification Center |
| 2018 | The first batch of Guangxi agricultural brands |
| 2017–2019 | A regional public brand in China's top 100 agricultural product brands |
| 2019 | Green certification |
| 2021 | Quality "positive" seal certification issued by Hong Kong Certification Centre |

The second leap occurred after year 2000, when plastic mulch was used in the cultivation. With advanced planting and reducing the diseases and insect damage, the yield was improved again. The simplified cultivation techniques, which are mainly based on the plastic mulch covering, one-time fertilization, have become the main cultivation mode of Lipu taro at present. In 2002, the plastic mulch covering cultivation technology won the first prize of Guangxi Department of Agriculture and the second-class prize of National Ministry of Agriculture.

## 4 Discussion and Conclusion

The unique subtropical geographical environment in the study case of Xiuren has bred Lipu taro with specific fragrance and taste. As a crop with both medicinal and food utilities, it can make up for the shortage of staple food production and shows broad development prospects. However, there are still a series of issues in Lipu taro cultivation and manufacture that need further attention, scientific research and policy support.

### 4.1 Main Concerns of Lipu Taro Development

The taro manufactures in Guangxi are usually in the state of insufficient investment in science and technology. The sustainable development of taro industry has been seriously restricted by the degradation of taro varieties, backward cultivation technology and product techniques. At present, the connection between taro scientific research and enterprises in Guangxi is relatively lack. Some key technologies in taro manufacture, such as variety screening, mechanization cultivation, disease and insect pest control, water, fertilizer, drug utilization and product processing and manufacturing technology, mainly rely on the traditional experiences of farmers or manufacture enterprises. Many processing enterprises report that taro has a strong flavor in fresh cooking, but the flavor is weak or disappears after it is processed into powder, which may seriously affect the quality of the original products. It is urgent to overcome these problems through scientific and technological development.

### 4.2 Expectation and Suggestion

Guangxi is adjacent to the Guangdong-Hong Kong-Macao Greater Bay Area, backed by the Southwest, and facing Southeast Asia. Guangxi's taro industry has broad market prospects in the Greater Bay Area. The Lipu administrations should take more critical roles in the industrialization of taro plantation, by strengthening the financial support and technique

guidance to taro breeding, environmental protection and sustainable development. It is suggested that the administration and enterprises should emphasize knowledge propagation, promote co-operation between industrial catenaries for continually improving product quality, and invest to scientific and technologic researches.

### *Author Contributions*

Mo, X. G. designed the algorithms of dataset. Sun, Z. W., Zhou, X. M., Mo, Y. W., Qiu, Z. Y., Li, Z. B., Qin, D. X. and Liu, X. M. contributed to the data collection, Liu, X. Y., Zhou, H. W., Nsigayehe, J. M. V and Hu, S. contributed to the data processing and analysis. Mo, X. G., Liu, S. X., Hu, S., Zuo, L. X., Su, Yan. and Xiong, H. M. wrote the data paper.

### *Conflicts of Interest*

The authors declare no conflicts of interest.

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