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Can Arable Land Alone Ensure Food Security? The Concept of Arable Land Equivalent Unit and Its Implications in Zhoushan City, China

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Abstract: The requisition–compensation balance of farmlands (RCBF) is a strict Chinese policy that aims to ensure food security. However, the process of supplementing arable land has substantially damaged the ecological environment through the blind development of grasslands, woodlands, and wetlands to supplement arable land. Can arable land alone ensure food security? To answer this question, this study introduced the concepts of arable land equivalent unit (ALEU) and food equivalent unit (FEU) based on the idea of food security. Zhoushan City in Zhejiang Province, China was selected as the research area. This study analyzed the ALEU supply and demand capabilities in the study area and presented the corresponding policy implications for the RCBF improvement. The results showed that the proportion of ALEU from arable land and waters for aquaculture is from 46:54 in 2009 to 31:69 in 2015, thereby suggesting that aquaculture waters can also be important in food security. Under three different living standards (i.e., adequate food and clothing, well-off, and affluence), ALEU from arable land can barely meet the needs of the permanent resident population in the study area. However, ALEU from aquaculture waters can provide important supplementation. Therefore, we suggest that food supply capability from land types other than the arable land be taken seriously. Furthermore, RCBF can be improved with ALEU as core of the balance.

Keywords: land management; balance of arable land; food security; grain security; China

1. Introduction

Arable lands are the type of lands capable to be ploughed and therefore are critical for grain production [1]. Thus, maintaining a certain extent of arable land is the basis and guarantee for food security in many countries. Among them, the Chinese government attaches great importance to this because of its large population. To maintain food security, the Chinese government ascribes immense importance to the protection of arable land. The land management law of China stipulates the implementation of the requisition–compensation balance of farmlands (RCBF) and declares to adopt the most stringent farmland protection policy in the world to "protect farmland just like pandas" [2]. One of the most important objectives of China's implementation of RCBF is to ensure grain security, which is the same as food security defined by the United Nations Food and Agriculture Organization (FAO, Rome, Italy). China's successful achievement of grain security in recent decades has resulted in serious damage to the environment upstream of the agricultural sector, on farm and downstream [3]. The environmental costs of this damage are not only agro-ecosystem function and the long-term sustainability of food production, but also bio-physical, including human health with impacts at all levels from the local to the global. So can arable land alone ensure food security? In fact, food security has been extensively translated to grain security in China [4]. FAO has defined food security in four critical dimensions: the physical availability of food, the economic and physical access to food, food utilization, and the stability of these three dimension. Depending on certain definitions, the concept of food security may not be applicable to China, since China's economy has developed rapidly. However, from a sustainability perspective, food security can be discussed for China as self-sufficiency, but the traditional concept of food security in China is considerably different from this international concept. The Chinese people have stressed the importance of grain security for a long time through such expressions as "grain in hand, no panic in heart." However, the single plant farming system in China confuses grain with cereal and confuses cereal with food as well. The idea that "food = cereal = grain" results in the concept of food narrowing when grain is merely a component of the entire food system [3]. The range of food is substantially wider than that of grain. The range of food is unconfined to grains and includes all calories, fats, proteins, and grain and non-grain food that humans need, such as meat and aquatic products [5]. In fact, animal husbandry and aquaculture are important sources of food supply [6].

The food structure that was once mainly based on grains has changed because of the general improvement in the living standard and dietary nutrition of people [7,8]. Béné et al. [9] determined that the protein supplied by fish indirectly guarantees food security for 10% of the world's population. Apart from significantly impacting food security, the change in dietary structure will also lead to a significant change in land use policies [10–14]. The utilization and protection of arable land resources, which are simply marked by grain production, can no longer match the current situation [3]. Unsuitable land that is forcibly reclaimed as arable land for grain production may bring failure to the security of food production and protection of land resources [15]. Therefore, the following steps should be taken for adjusting the dietary structure of China's population: (1) depart from the food security concept of "taking grain as the key link to food security"; (2) focus on all land requirements for food, including arable land [16]; (3) form the concept of "new food systems and modern agriculture"; and (4) gradually change the current concept of arable land protection.

Ren et al. [3] proposed the Arable Land Equivalent Unit (ALEU) as a dimension to use the comprehensive index for the food production of land to reflect food production potential. ALEU is based on annual rice production in monoculture, thereby enabling the evaluation of the relative food productivity potential of all agricultural lands, including traditional and non-traditional farmlands (e.g., grassland and aquaculture water). The essence of ALEU is the area representation of land food production [15]. China's ALEU in 2020 is expected to increase by 0.79×10^8 hm^2 through the development of grassland agriculture [17]. This value could actually meet China's long-term planning target of 7×10^8 t food equivalent units [15]. Li et al. [18] calculated the food production potential of grasslands in the six major pastoral areas of China based on ALEU and Food Equivalent Unit (FEU). Compared with the food production capability of the current agricultural system, the results showed that ALEU of the grassland agriculture model in the six major pastoral areas may increase by 1514.24×10^4 hm^2. Hong et al. [19] used the FEU computing methods to calculate the annual yield of oil crops in China in 1999–2008.

Zhoushan City in Zhejiang Province is the first national new area in China with a marine economy theme. Given the implementation of the development plan of new areas in Zhoushan Islands, Zhejiang Province, the large-scale occupation of farmlands by construction will be difficult to avoid in the future. However, the reserves of arable land suitable for reclamation in Zhoushan are considerably insufficient and fresh water resources in the area are scarce. Zhoushan City has marine space resources that are substantially endowed by nature with 183.19 km^2 of tidal flat that is equivalent to the arable land area. Fishery production accounts for 91.31% of the primary industry and aquatic products account for a large portion of the local diet structure. In the long term, the normalized and standardized breeding ponds (bases) in Zhoushan have the same function as the basic farmland. If the tidal flat is reclaimed for arable land to achieve RCBF in this area, then reclaimed land is difficult to use for agriculture because such land lacks fresh water resources and has imperfect water conservation facilities [20]. The benefit of agricultural cultivation is also poor with a net income of merely 9000 yuan/hm^2. If the land was used for aquaculture, then income per hectare would reach 150 thousand yuan [21]. By contrast, the large-scale reclamation of tidal flats destroys original habitats of all types of plants and animals. Most importantly, the living environment that is suitable for the life of the tidal flat surface is also destroyed, thereby accelerating the degradation of the biological resources of the tidal flat wetland [22].

Therefore, from the original intention of the RCBF, which is to protect food security, the current study introduces the concepts of ALEU and FEU, employs Zhoushan City as a study area, and attempts to positively analyze the supply and demand capacity of ALEU in this area to present recommendations for the improvement of RCBF.

2. Materials and Methods

2.1. Study Area and Data

Zhoushan City is the first prefecture-level city formed by islands in China (Figure 1). The city has small land and large sea areas. The total area of Zhoushan City is 2.22×10^4 km^2, of which the sea and land areas are 2.08×10^4 km^2 and 1.4×10^3 km^2, respectively. In 2015, this city had a permanent and household populations of 1.152×10^6 and 9.736×10^5, with an urbanization rate of 66.3%. The regional GDP was 109.29 billion yuan. In accordance with the development plan of new areas in Zhoushan islands, Zhoushan City will become the center of commodity storage, transportation, processing, and trading in China. Zhoushan City will also be an important modern marine industrial base and a leading area that promotes future land and marine development in a coordinated manner. Arable land in Zhoushan City is concentrated in areas between hills of the main islands and coastal flat areas. The proportion of basic farmland is as high as 96%. Moreover, a high coincidence degree exists between the concentrated areas of basic farmland and planning areas of the marine economic industry.

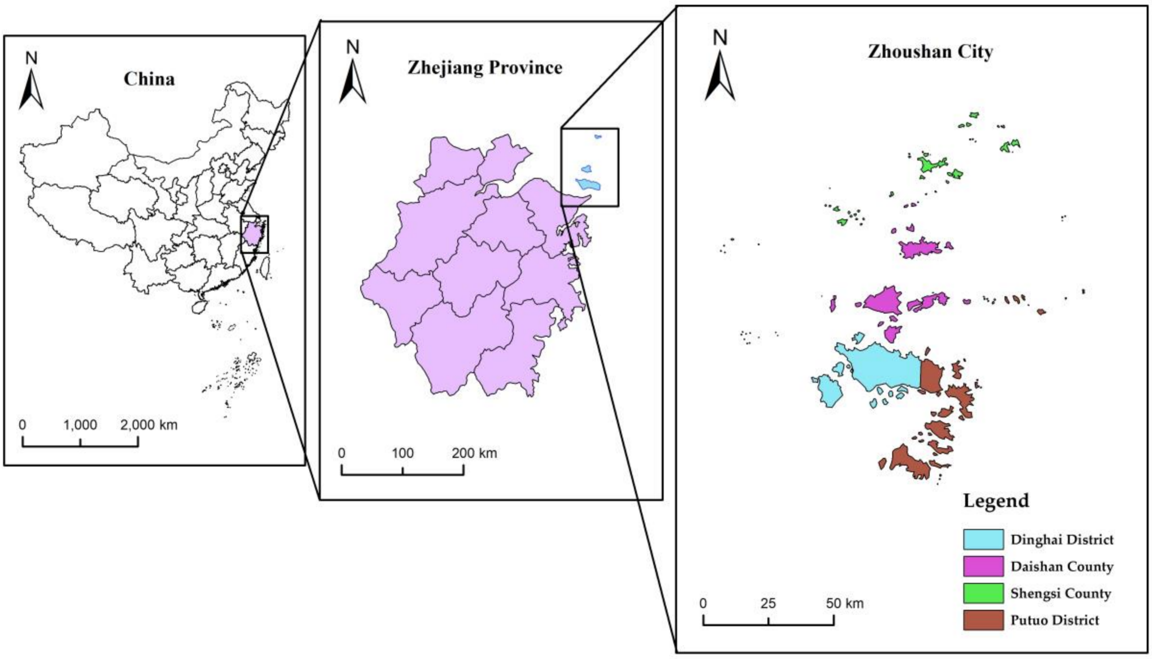

Figure 1. Study area.

The area data of arable land in the study area is from the second national land use and land use status update surveys of China in 2010–2015. The crop planting area and the output of rice, corn, and sweet potatoes among others, as well as all types of seawater aquaculture areas and their yield are obtained from the Zhoushan Statistical Yearbook of 2010–2016. The nutritional content of various foods is obtained from the Chinese food composition table of 2015.

2.2. Methods

2.2.1. ALEU and FEU

The essence of ALEU is the area representation of food production [15] that evaluates the relative potential food productivity of arable and non-arable land resources based on the annual rice production in monoculture. To determine the appropriate ruler and simplify the calculation, we need to combine the concept of FEU to unify the output attributes of food based on the content of certain food ingredients. Therefore, FEU is combined based on the heat and protein content. Although vitamins and other micronutrients are also necessary for survival, they are temporarily not considered in FEU for ease. The formula for calculating FEU is as follows:

$$FEU = (H \times E)1585 + P \times E/77, \quad (1)$$

where H and P are calorie (kcal) and protein (g) content, respectively, of food per unit weight (kg) and E is the edible component of this food.

For example, Formula (1) indicates that the FEU of rice per unit weight is 2.04 and that of mussels per unit weight is 0.88. The method of calculating the FEU of other food crops and marine products is similar to this method. Thus, we can acquire the total FEU of a region based on the total output of food crops and marine products in that area. For reference, we use the average unit output of rice in the study area of 7004 kg/hm^2 in the last five years. The theoretical two-harvests-a-year multiple crop index indicates that 1 hm^2 ALEU can produce 28,576 FEU. That is, 0.35 hm^2 ALEU is required to produce 10,000 FEU. Therefore, the total ALUE of the region can be obtained from the total FEU of the same region.

2.2.2. Demand for ALEU Per Capita

The demand for ALEU per capita can be divided based on living standards. On the basis of the actual situation in China in the 1990s, the research group of the China food mid-term and long-term developments proposed the goal of dietary nutrition and consumption demand for main food in four stages, namely, adequate food and clothing, moderately well-off, well-off, and affluence [23]. In addition, several scholars have divided the living standards in China depending on different perspectives and have set the reference value of nutrition [24–26]. The living standards of residents are divided from low to high into three grades, namely, adequate food and clothing, well-off, and affluence, by referring to the aforementioned classification standards and combining the requirements of China in building an overall well-off society by 2020. This study divides the demand for ALEU per capita into the three different levels in accordance with different standards of living. Thereafter, the current study referred to Wang et al. [6] to calculate the per capita demand of different levels for calories and protein annually. Lastly, this demand is used to obtain the demand for ALEU in accordance with the calculation method of FEU (Table 1).

Table 1. Demand in annual food nutrients and arable land equivalent unit (ALEU) per capita.

Level	Calories (kcal)	Protein (g)	ALEU (hm^2)
Adequate food and clothing	835,485	28,105	0.031
Well-off	837,675	29,565	0.032
Affluence	856,655	31,390	0.033

3. Results

3.1. ALEU Supply in the Study Area in Recent Years

3.1.1. Supply of ALEU from Arable Land

Arable land is the most important source of food for humans and is also one of the main food sources for the residents of the study area. The food supply capability of arable land is particularly important based on the guiding ideology of food security that specifies that the grain is self-sufficient and that the ration is absolutely safe. On the basis of the actual situation of the study area, the current study chooses four main cultivated crops (i.e., barley, rice, corn, and sweet potato) and calculates their total FEU in the study area (Figure 2) by applying Formula (1) to the Chinese food composition table of 2015.

Figure 2 shows that the total FEU from the arable land in the study area exhibited a substantial downward trend from 2009 to 2015, which is positively related to the entire area within the study area that was sown with grain. In 2009, the area sown with grain crops within the study area was 1.252×10^4 hm^2, which decreased to 6.12×10^3 hm^2 in 2014. Although many reasons exist as to why the grain-sown area was reduced, the abandoned arable land and the decrease in arable land area accounts for a large proportion of its causes. Rice is the most important source of total FEU, thereby accounting for approximately 60%, followed by corn that accounts for approximately 33% of the total. These results are closely related to arable land using a structure with increased proportions of dry land in the study area. In addition, about 90 hm^2 of arable land was used to grow barley instead of rice in 2013, resulting in a sudden peak in the FEU of barley in 2013.

In accordance with the aforementioned conversion relationship between FEU and ALEU, the total FEU of the four major crops from the cultivated land was converted into the total FEU from arable land in the study area (Figure 3). Figure 3 shows evident differences in the ALEU supply from arable land in each county of the study area. Dinghai District had the highest average supply, thereby accounting for approximately 60% of the total average, followed by Putuo District; that of Shengsi County was the lowest. Among the varying trends, all districts and counties, with the exception of Shengsi County, exhibited an increased decline. In particular, the ALEU of Putuo District had decreased by over 45%.

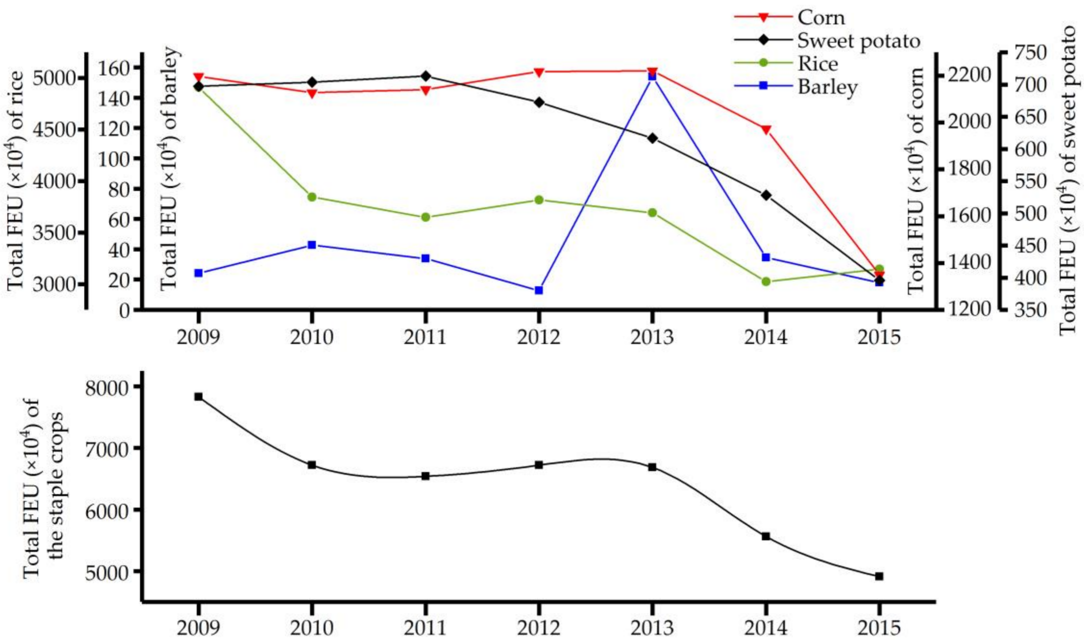

Figure 2. Total food equivalent unit (FEU) of the staple crops from arable land in Zhoushan City from 2009–2015.

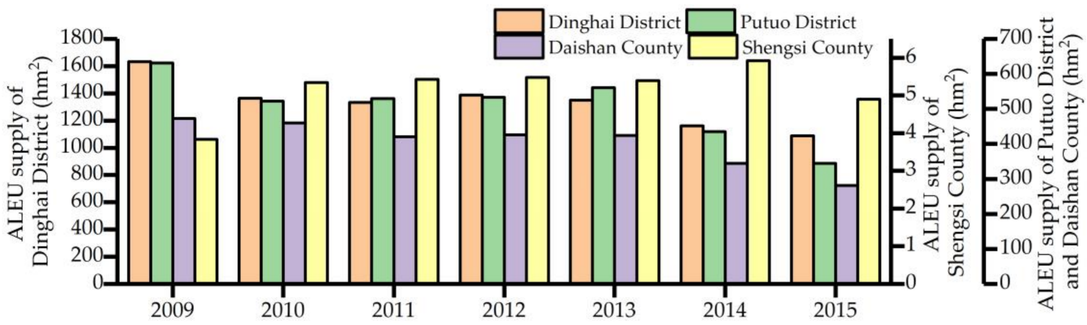

Figure 3. ALEU supply from the arable land in the counties/districts of Zhoushan City from 2009–2015.

3.1.2. ALEU Supply from Waters for Aquaculture

The study area is known as the "fish storehouse of East China Sea" and the "fish capital of China," as the Zhoushan fishing grounds are one of the four largest in the world and are rich in aquatic resources. Aquaculture products in the study area are mainly razor clams, mussels, clams, snails, shrimp, kelp, and seaweed, particularly mussels; hence, the area is also known as the "hometown of mussels." The total FEU of these seven major marine products were calculated (Figure 4) by applying Formula (1) to the Chinese food composition table of 2015.

Figure 4 shows that the total FEU from the waters for aquaculture in the study area in 2009–2015 were generally increasing. In fact, the low total FEU in 2011 was caused by a typhoon, thereby leading to the destruction of farming facilities and escape of aquaculture products. These results are not caused by the expansion of waters for aquaculture in the study area because these waters had actually been shrinking. The increase in the total FEU from the waters for aquaculture was closely related to many factors, such as the recent construction of standard aquaculture ponds in the study area to improve the production conditions of ponds and technical progress of aquaculture and improvement of breed.

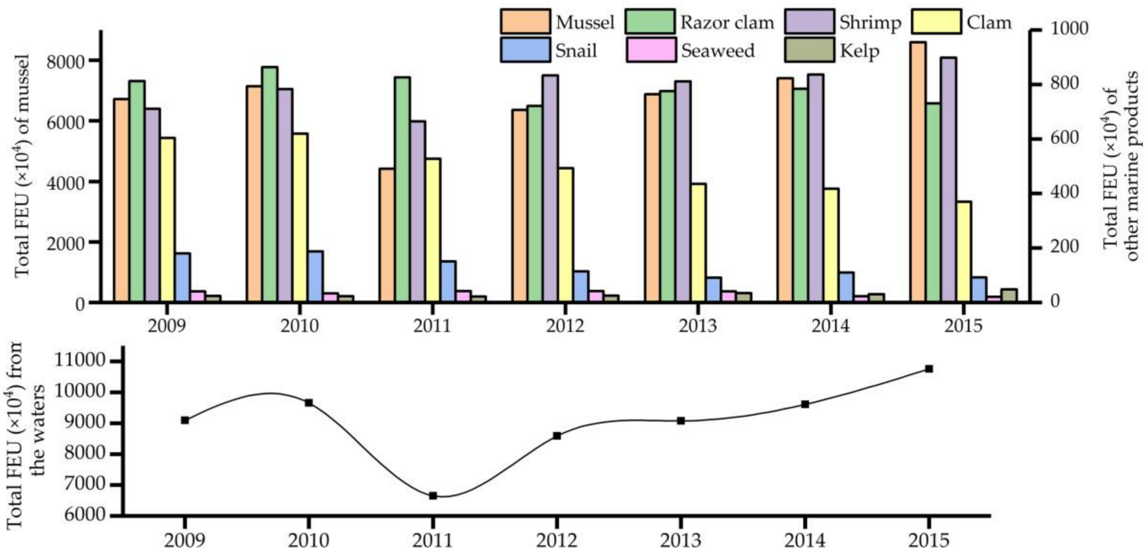

Figure 4. Total FEU from the waters for aquaculture in Zhoushan City from 2009–2015.

In accordance with the preceding conversion relation between FEU and ALEU, the total FEU of the seven major marine products derived from the waters for aquaculture was converted into the total ALEU from the waters for aquaculture in the study area (Figure 5). Figure 5 shows evident differences in the ALEU supply from the waters for aquaculture in each county of the study area. Shengsi County had the highest average supply, which accounts for over 70% of the total average supply, followed by

Putuo District; that of Dinghai District was the lowest. For the variation trend, that of Dinghai District declined by 37%, Putuo District and Daishan County only slightly changed, and Shengsi County increased by approximately 28%.

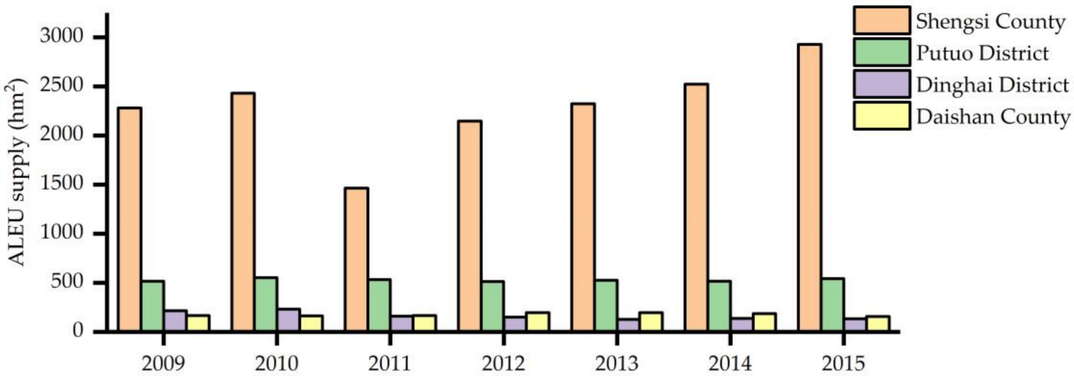

Figure 5. ALEU supply from waters for aquaculture in the counties/districts of Zhoushan City from 2009–2015.

3.1.3. Analysis of the Total ALEU Supply and Structure

Figure 6 shows that the total supply of ALEU in the study area in 2015 was 5481.37 hm^2. Shengsi County accounted for over half of the total supply, followed by Dinghai District; Daishan County had the lowest supply. From 2009 to 2015, the total supply of ALEU in the study area showed a downward trend with a decrease of 7.44%. All counties and districts declined in ALEU, except for Shengsi County, which increased by 28.39%. The descending rate of Dinghai District was the highest at over 33% (Figure 6).

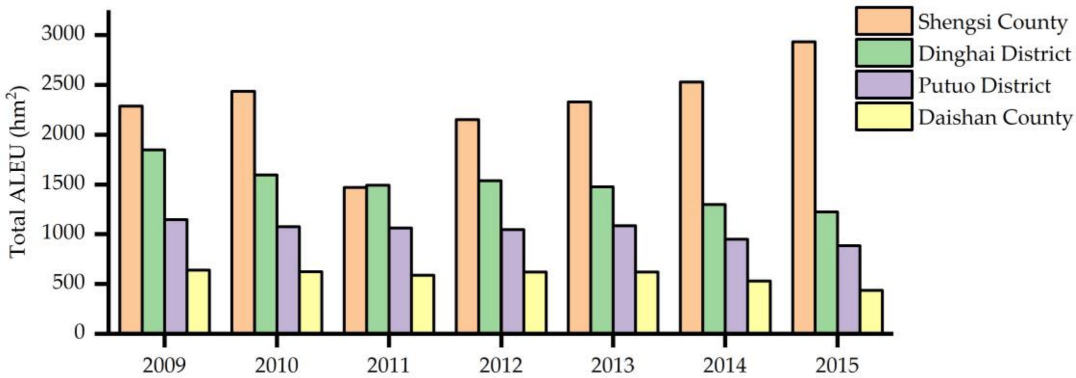

Figure 6. Total ALEU in the counties/districts of Zhoushan City from 2009–2015.

In 2015, the permanent population of the study area was at 115.20 $\times$ 10^4. The calculation of the three different living standards (i.e., adequate food and clothing, well-off, and affluence) indicates a substantial ALEU supply gap and the proportion of such gap was approximately 85%. This result shows that the food and nutrition provided by local arable lands and aquaculture waters in the study area could not meet the needs of the resident population (Table 2).

A considerable gap exists between the ALEU supply of arable land and the waters for aquaculture. The proportion of the former in the total ALEU of the study area showed a downward trend and decreased by 14.93% in 2015 from ALEU in 2009 (Figures 7 and 8). This phenomenon mainly manifested in the decline of supply in Putuo District and Daishan County, whereas the ALEU supply of the other two counties remained unchanged.

Table 2. Demand for and supply of ALEU in Zhoushan City in 2015 under different standards of living.

Living Standard	Demand for ALEU Per Capita (hm^2)	Total Demand for ALEU (hm^2)	Gap (hm^2)	Gap Proportion (%)
Adequate food and clothing	0.031	35,712	30,231	84.65
Well-off	0.032	36,864	31,383	85.13
Affluence	0.033	38,016	32,535	85.58

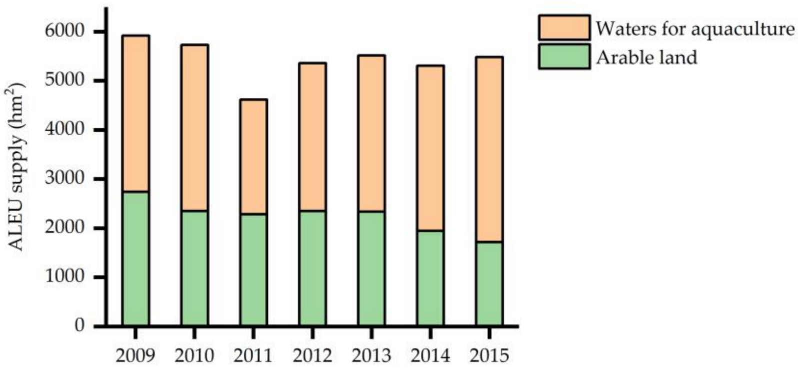

Figure 7. Change in the ALEU supply from different sources in Zhoushan City from 2009–2015.

The proportions of ALEU from the arable land among the different counties significantly differ from one another. Dinghai District accounts for the highest proportion at 89%, followed by Daishan County at approximately 70%. The proportion of Shengsi County ALEU was the lowest at only 0.22% of the total (Figure 8).

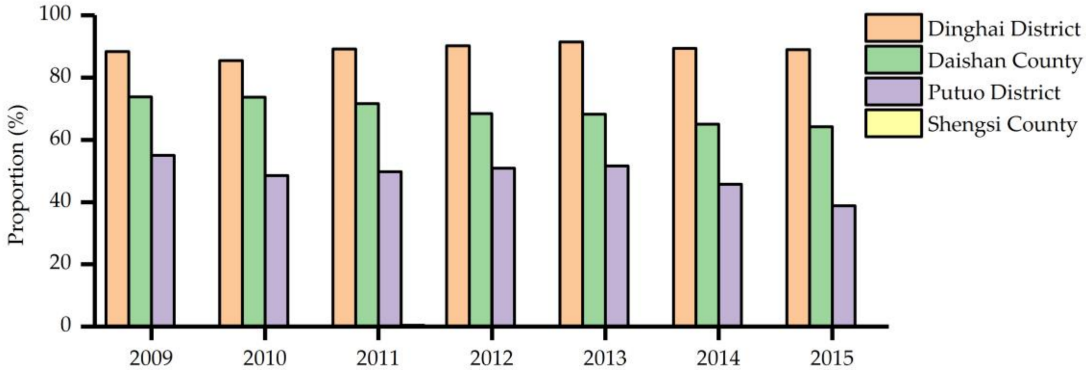

Figure 8. Proportion of the ALEU supply from the arable land in Zhoushan City from 2009–2015.

3.2. Analysis of the Future ALEU Supply and Demand in the Study Area

3.2.1. Analysis of the Future ALEU Supply Potential

The capacity for future ALEU supply in the study area comprises two components, namely, the supply from arable land and that from the waters for aquaculture. The ALEU supply potential can be estimated by using the arable land area and grain yield per unit area. We may predict the area of paddy fields and dry land in the study area and its districts and counties in 2020 based on the revision of the overall plan for land utilization in Zhoushan City (2006–2020). The paddy field is used to grow rice and dry land is used to interplant corn and sweet potato. Although Shengsi County does not produce rice and corn, we can take the yield of Daishan County as an alternative because the latter has conditions that approximate those of the former in every aspect, such as geographical environment. The paddy field multiple crop index is set to two based on the average yield per unit area in the last five years, thereby enabling the determination of the total FEU and ALEU potential from the arable land (Figure 9).

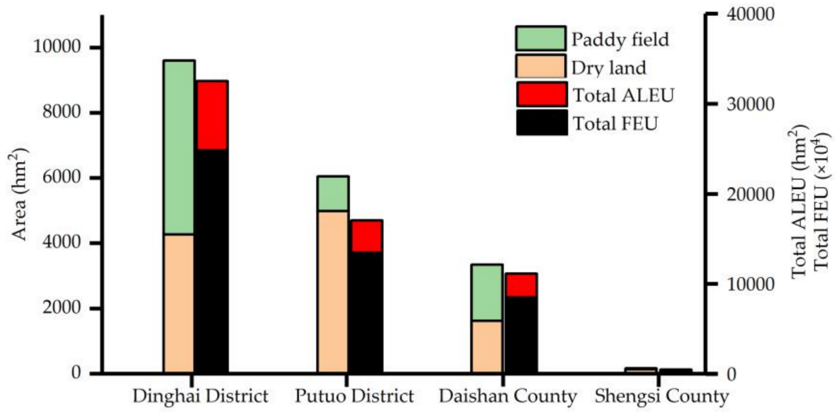

Figure 9. Supply potential of the total FEU and ALEU from the arable land in Zhoushan City in 2020.

In 2020, the supply potential of ALEU from arable land is predicted to reach 14,015.16 hm^2, over half of which (55%) will be from Dinghai District. Putuo District follows at 25% and the lowest ALEU supply potential is predicted to be from Shengsi County at only 0.72%. The arable land in the study area has a higher ALEU supply potential than the actual ALEU supply in 2015.

In recent years, aquaculture waters in the study area have been shrinking. In fact, they have decreased by 25% (2199 hm^2) in 2015 from the 7978 hm^2 in 2009. However, aquaculture output increased by 14,299 t (11.22%). The total FEU per unit area also increased by 63% with an average annual growth of 10% (Figure 10). Accordingly, the potential for aquaculture production per unit area will increase with the construction of standard culture ponds and improvement of marine aquaculture technology. If the growth rate of the yield per unit area in recent years and of the breeding area in 2015 are maintained, then the area of waters for aquaculture in 2020 can provide an FEU of 16,446 $\times$ 10^4, which is 5756.06 hm^2 if converted to ALEU. In this manner, the total ALEU of arable land and waters for aquaculture in the study area will be 19,771.22 hm^2 in 2020.

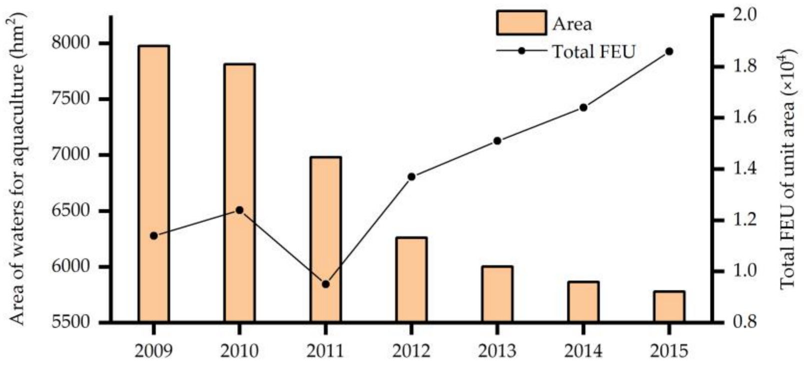

Figure 10. Total FEU of the unit area of the waters for aquaculture in Zhoushan City from 2009–2015.

3.2.2. Balance Analysis of the Future ALEU Supply and Demand

The permanent population of Zhoushan will be 1233.3 thousand based on the revision of the overall plan for land utilization in Zhoushan (2006–2020) and the overall plan of the new area in Zhoushan island, Zhejiang (2012–2030). Table 3 shows that a substantial ALEU supply gap under different nutrient levels will exist in the study area in 2020 and the proportion of the gap will be approximately 50%. The statistics indicate that the potential of the local arable land and aquaculture waters to provide food and nutrition in the study area cannot meet the demand of the resident population. However, the gap will decrease by over 30% from that in 2015. Evidently, the study area has a vast sea area. In 2015, the marine fishing production of the area was approximately 11.4 times the yield of the marine aquaculture products. The ALEU that the area could provide in 2015 is 3.17 times the total ALEU from the arable land and aquaculture waters in the study area in 2020.

Table 3. Demand for and supply of ALEU in Zhoushan City in 2020 under different standards of living.

Living Standard	Demand for ALEU Per Capita (hm^2)	Total Demand for ALEU (hm^2)	Gap (hm^2)	Gap Proportion (%)
Adequate food and clothing	0.031	38,232	18,461	48.29
Well-off	0.032	39,466	19,694	49.90
Affluence	0.033	40,699	20,928	51.42

4. Discussion and Conclusions

The present study selected Zhoushan City as its study area. Upon introduction of ALEU and FEU, this research analyzes the ALEU supply and demand ability of the study area. From 2009–2015 in the study area, the total ALEU from the arable land decreased by 37.3% and that from the waters for aquaculture increased by 18.3%. The proportion of the total ALEU from the arable land decreased from 46.3% in 2009 to 31.4% in 2015. This result shows that the decrease in grain production caused by an increased proportion of abandoned land and a decrease of arable land area is becoming increasingly evident. Although the area of waters for aquaculture in the study area is decreasing, the production conditions of the ponds are improved by the construction of standard ponds. The total ALEU from waters for aquaculture continues to increase together with impact factors, such as technological progress and breed improvement. Under the three different living standards (i.e., adequate food and clothing, well-off, and affluence) and depending on actual capabilities or future potential, an approximately 50% gap exists in the ALEU provided by the local arable land and waters for aquaculture in the study area. This result indicates difficulty in satisfying the demand of the permanent population. However, if fishing products are included, then a surplus will arise. Arable land alone does not guarantee food security.

Recognizing the challenges of food security, the RCBF policy measures are being undertaken by the Chinese government. However, the current policy measures are unreasonable. Different regions have different characteristics of resource endowment, and forcing the balance of arable land could result in serious ecological damage. Arable lands are important, but crop yields are not just the consequence of land availability. From one side, the edaphic aspect of lands (nutrients contents), the use of fertilizer can substantially increase yields. From the other side, unpredictable climate features such as droughts can have drastic impacts on food security regardless of the arable land availability [27]. Meanwhile, the sustainability of irrigated agriculture is also challenged by the rising water demand from urbanization and ecological civilization construction and water pollution [28]. Therefore, we need to revise the RCBF policy from the perspective of ensuring food security, not grain security. The main proposals and solutions for the 2020 and next time period obtained from the present study are as follows.

(1) The food security concept must be changed in China and importance must be given to the food supply capability of the land type rather than the arable land. Water for aquaculture is the main source of food supply in the study area. As food sources and demands increase in diversity, the introduction of ALEU and FEU unifies the dimension of the grain output FEU and aquatic product output and the dimension of the ALEU supply capacity of arable land and aquaculture water areas. In addition, some scholars have calculated the ALEU of grassland, and found that it can provide a large amount of feed and livestock, which is also an important part of food security [17–19]. Such unification can provide a new perspective for the improvement of RCBF

for food security maintenance. It can also be useful for countries and regions with a shortage of arable land resources.

(2) The construction of high-standard arable land and high-standard aquaculture ponds should be promoted and the ALEU supply capability of the existing arable land and aquaculture ponds should be enhanced. Climate change will have an impact on the ALEU supply capability of arable land and aquaculture ponds. Therefore, in response to the present situation in the study area in terms of high frequency of natural disasters, we can further promote the construction of high-standard farmlands. We can also increase the ALEU per unit area supply capability and promote RCBF with an arable land–productivity balance. Meanwhile, we should implement the policy that enables high-standard aquaculture ponds to enjoy the same status as the high-standard basic farmland. The policy also energetically constructs high-standard aquaculture ponds and raises their ability to withstand natural disasters to increase the ALEU supply capability per unit area of aquaculture waters.

(3) Arable land protection should be intensified and diversified forms to realize RCBF should be explored. Given the establishment and construction of the new area of Zhoushan Islands in Zhejiang, Zhoushan City will face the unprecedented contradiction between the protection of arable land resources and the guarantee of construction land. On the one hand, enhancing the existing farmland protection effort through the establishment and improvement of compensation mechanisms for farmland protection is also suggested. The study area officially issued a notice on the establishment of a compensation mechanism for farmland protection at the end of 2016 and it was the latest to establish such a mechanism in Zhejiang Province. In the future, emphasis should be placed on the methods of effectively improving and implementing the compensation mechanism of farmland protection and on formulating relevant supporting policies. On the other hand, reserved arable land resource in the study area is extremely scarce. The survey data on such resource shows that the area is only 1788.84 hm^2 [29]. Moreover, the freshwater resource is scarce and the amount of water resource is 55.03×10^4 m^3/km^2, which is only 60% of the average level in Zhejiang Province. The water resource per capita is 707 m^3, which is only 33% of the per capita level of Zhejiang Province [30]. Nevertheless, the reclamation of tidal flat and salt lands will continue to be the main methods of supplementing arable land and realizing RCBF [31]. However, from the history of reclamation in Zhoushan City, salt land or breeding ponds were built first and they gradually evolved into arable land thereafter with the improvement of soil. The tidal flats developed through concentrated reclamation in recent years may only be used for aquaculture [21,32]. Therefore, the newly increased aquaculture waters from tidal flats developed by reclamation should be identified beforehand as newly increased arable land. Simultaneously, quality management should be strengthened to ensure an increased level of food production capacity per unit area. Doing so will guarantee the food production capability of the study area and other regions with similar problems and facilitate the maintenance of regional ecological security. Countries and regions similar to Zhoushan City, especially developing countries, can explore similar ways to ensure food security.

(4) The defects and applicable scope of the RCBF policy at the national level should be reconsidered and an improvement path should be explored. The implementation of RCBF has positively affected farmland protection in China. From 1997 to 2011, the increased arable land through consolidation, reclamation, and development was 442.73×10^4 hm^2. This result indicates that the annual supplementary arable land area is larger than the requisition for construction in the entire country [33,34]. However, the balance of arable land requisition and compensation is one-sidedly pursued at the expense of the ecological environment. The blind development of grasslands, forests in mountains, and wetlands in tidal flats has seriously damaged the structure of the ecosystem, with several even causing natural disasters, such as soil erosion, soil desertification, and floods. The newly developed farmland itself is also threatened by natural disasters [35]. Therefore, reconsidering the RCBF is necessary. Such policies as the ALEU

requisition–compensation balance should be implemented in certain pilot areas based on the carrying capability of resources and the environment, reserves of arable land, and the potential of increasing arable land by consolidation, among others. Other countries and regions need to pay attention to ALEU when ensuring food security, not just the balance of the quantity of arable land, so as to reduce the damage to the ecological environment.

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