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Assessment of the EU market farms sustainability based on a composite sustainability index

Veselin Krustev

Agricultural Academy, Institute of Agricultural Economics,1113 Sofia, Bulgaria
Corresponding author: veselin.krustev@gmail.com

Abstract

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The fundamental understanding of sustainability in agriculture is clarified and elaborated in a broader definition, according to which conceptually agriculture should become ecologically compatible as remaining economically efficient and socially responsible at the same time. It turns out that in last decades, the agricultural production entities in EU are under transformation due to market and regulation factors, which results in increase of their economic size, leading into a shrink in their number. Does this process escalades crucially the farming preservation or boosts economically their sustainability?

This study aims to find out and analyze the connection and characteristics between the farms size in economic classes and changes in their sustainability index aiming to illustrate the EU differences between the all Member States expressed as holdings.

The results, extracted from the FADN data, could reveal a potential of the smaller farms to exist and run sustainably while the bigger units face severe threats to incur ecological damages in pursuing better production efficiency.

Keywords: European Union; Agricultural Holdings; Farm Sustainability; Economic Size

Introduction

The indispensability to construct a sustainability scoring system resulting in composite index that involves a usage of sufficient quantitative indicators is widely discussed (Bachev et al., 2019; De Oliveira, 2018; Ramírez-Carrillo et al., 2018; Hayati et al., 2010; Bohlen & House, 2009; Sauvenier et al., 2006). However, the three pillar indicators sometimes might not even support each other. The farms sustainability insists on an ecologically improved production technology that is enough intensified to be economically efficient and socially acceptable and reliable. The agricultural sustainability estimations that include its main fundaments are a vast number in the empirical studies (Dessart et al., 2019).

Ivanov et al. (2009) proofed that the most important part of sustainable development is the agricultural sustainability as a challenge to find out if there is a way farms to boost all three pillars of sustainability to a sufficient or even high level without a compromise? Discussion of the principles and criteria for selecting appropriate indicators for assessing sustainability has been widely advocated in the literature (Hodge & Hardi, 1997; OECD, 1994; Atkinson et al., 1997; Radke, 1999; Pretty, 2018) over the past four decades.

Apart from the content requirements, there are detailed, significantly more practical prerequisites for the operational use of sustainability indices for the needs of the policies and their measures they would suggest among all possible ones. It would be advisable to build the indices so that reforms can be based on them and the traceability of their construction (Böhringer & Jochem, 2006; Kuik & Gilbert, 1999; Hammond et al., 1995). Such a formula is presented by Ivanov (2023) for accumulating set of variables into a composite index that take place in the method for constructing the Relative Comparative Assessment index in this paper.

The Ethiopian researcher Mutyasira (2017) aiming to synthesize the selected indicators in a relative farm sustainability index, with the presumption to reduce subjectivity in the index construction, applies DEA to calculate sustainability scores. He reveals the farm size and the access to farm expansion are some of the key drivers for increasing the sustainability at the farm level.

The challenge of providing some guidance to policy makers who intend to design sustainability-enhancing and green agricultural policies represents the assessment of the impact of a range of variables on agricultural sustainability. The most papers dedicated to sustainability assessment are focused on eco-environmental component. Furthermore, in this paper the sustainability is evaluated through the estimated main detrimental production factors, farm intensification level and the well-being of holdings, based on their costs.

The above cited researches are basic of a profound research examination, a set of 15 compounded indicators, which are consisted of 46 single variables extracted from the Farm Accountancy Data Network dedicated into three pillar sustainability assessment dimensions. Such an indicators take place in this research constructed by two independent elaborations – a Data Envelopment Analysis model (Krustev & Fidanska, 2022) and the Relative Comparative Assessment (Ivanov, 2022; Krustev, 2022). In order to apply those methods, some corrections and adjustment are needed in terms of used variables to solve the limitations of research due to scarcity of variable diversity and inadequate addressing of FADN database to aspects beyond economic matters.

Materials and Methods

The order of arrangement on the figures in this paper is based on the economic size of the inspected units. The time period is collected within the last two programs of the Common Agricultural Policy from where is estimated the average farm economic size besides the limited reversibility of its enlargement.

Data Envelopment Analysis

DEA creates virtual producer on the production border combining the most efficient decision making units (DMUs) of the sample (2007-2019) so there is a possibility several units to present the greatest results (Berg, 2010). Every other score computed by the program is presented as a coefficient according to the distance from the best indicators combination between 0 – 1.

In order to use the tool reliably, the "Benefit-of-the-doubt" approach was applied for the 15 indicators to be used simultaneously. These indicators were used in the sustainability modelling as outputs while ignoring the inputs of the production system (Cherchye et al., 2006). Also 5 indicators were used as outputs for the pillars assessment in the same order. The farm sustainability is estimated using input oriented and assuming constant returns to scale (CRS) DEA model. The sustainability estimations are received by the technical efficiency scores computed for the EU sample of average statistical farms referring to the FADN survey for the period from 2007 to 2019, which are representing the structure of the national economies. All the 4 indices calculated by DEA represent independent estimations of different number of variables (3 × 5 and 1 × 15). When adding more inputs or outputs the efficiency computation becomes more complex. (Charnes et al., 1978).

Relative Comparative Assessment

The following ranking and normalization formula was applied to design the indicator (Table 1) scores to fit between 0 and 1:

$$\text{Indicator Score} = \frac{\text{FADN Value}}{AVG + \text{St Dev}} * (0.5 + 0.5 * CV^2),$$

where Coefficient of Variation (*CV*) = Standard Deviation (St Dev)/ Average (*AVG*)

As a consequence, the scores needed the following restrictions:

A. value < 0 = 0 B. value >1 = 1

The sustainability assessment is calculated as an arithmetic average of the results by pillars, which in turn present the sustainability result as the average of all indicator scores.

Trying to construct the index through the prism of the standard deviation and the average values of every indicator involves a cut of some extreme peaks. In order to avoid such spikes – when the highest variable is several times higher than the second highest value – the Farmhouse Consumption (Slovakia 2007 is more than 6.5 higher than Slovakia 2008), the selected value is going to be set in lower figure. The same is observed in a negative attitude. The Family Farm Income per Family Working Unit in Denmark (2008 & 2009) have strong negative values (about 55 000 euro per member) and this irrational figure should be accepted as 0 aiming to keep the sample measurability.

Results and Discussion

Economic pillar

The small (family) business farms (up to 25 000 EUR Standard Output) stay below the EU average. Romanian

Table 1. Principles and criteria of the used indicators

Principle	Criteria	RCA Indicator	Ref.Value	DEA indicator	Ind.Type
Economic efficiency	Maximizing labour productivity	Labour Productivity = Total gross output / Total labour input	EU average	Total labour input	More is better
	Risk management/ Maximizing profitability	2. Production Diversification = 1 – [(Max Output – Avg Output) + (Avg Output – Min Output)] / Total Output)	EU average	Total livestock output / Livestock Units	More is better
Financial stability	Positive profitability	3. Profitability = Farm Net Income / (Total Inputs – Farm use)	EU average	Total Utilised Agricultural Area	More is better
	Maximizing capital productivity	4. Capital productivity = Total gross output / Average farm capital	EU average	Total assets	More is better
Economic Viability	Adaptability to economic environment	5. Economic Resilience = (Total Output – Total Subsidies) / (Other direct inputs + Depreciations + Total External Factors) (Bachev et al., 2017)	EU average	Total gross output	More is better
Principle	Criteria	RCA Indicator	Ref. Value	DEA indicator	Ind. Type
Welfare of employed in agriculture	Sufficient satisfaction from farm activity	6. =Family Farm Income / Family Working Units	EU average	Family Farm Income / Family Work Units	More is better
	Social remuneration in kind	7. =Farmhouse consumption / Unpaid labour input	EU average	Farmhouse consumption	More is better
	Sufficient satisfaction from farm activity*	8. =Wages paid / Paid labour input	EU average	Wages paid / Paid labour input	More is better
Conservation of farming	Share of own land as a source of farm conservation	9. = 1 – (Rented Area / Total Utilised Agricultural Area)	EU average	Gross Farm Income*	More is better
	Sufficient satisfaction from farm activity	10. =Farm use / Total Utilised Agricultural Area	EU average	Farm use	More is better
Animal welfare	Complience with the principles	11. =Stocking density	EU average	Stocking density	Less is better
Land quality	Minimizing soil losses	12. = 1 – (Fertilisers / Intensified area*) * = Arable Land + Permanent Crops	EU average	Fertilisers	Less is better
		13. = 1 – (Crop protection / Intensified area*)	EU average	Crop protection	Less is better
	Good agricultural practices	14. =Protein crops / (Cereals + Energy crops + Potatoes + Sugar beet + Oil-seed crops + Industrial crops + Vegetables&flowers)	EU average	Protein crops / Total output crops & crop production	More is better
Air quality	Reduction of CO2 emissions	15. = 1- (Energy / Total Utilised Agricultural Area)	EU average	Energy	Less is better

The Gross Farm Income to be concerned as Sufficient satisfaction from farm activity indicator
Source: FADN

holdings improved sharply their labour productivity by 51%, but that is accompanied with a loss of agricultural farms, whereas the economic size of farms rise by 143%. Greek farms gain a significant level of economic sustainability as an old Member State, but the followed slight decrease seems to be continuous caused by serious decline in the profitability (-25%) and capital productivity (-22%). Slovenian agricultural units could not move significantly their economic level, but the diversifications level and labour productivity has increased (respectfully +5% and +35%) while the other indicators got lower values within 10%. Croatia`s farms demonstrate a permanent economic increase resulting after labour productivity and profitability improvement (Figure 1).

Most of the small-medium farms did not gain an increase (6 out of 8). The exceptions – Malta and Cyprus have top results which is characterized by their land limitations and respectfully intensive farm specialization but in particular their basis is the economic conjuncture resilience. That indicator is raising also in Ireland (+90%) and Portugal (+15%), supported by the positive development of the profitability. Latvia and Poland share a same curve trend which becomes very close to the reference powered by a labour productivity and production diversification acceleration.

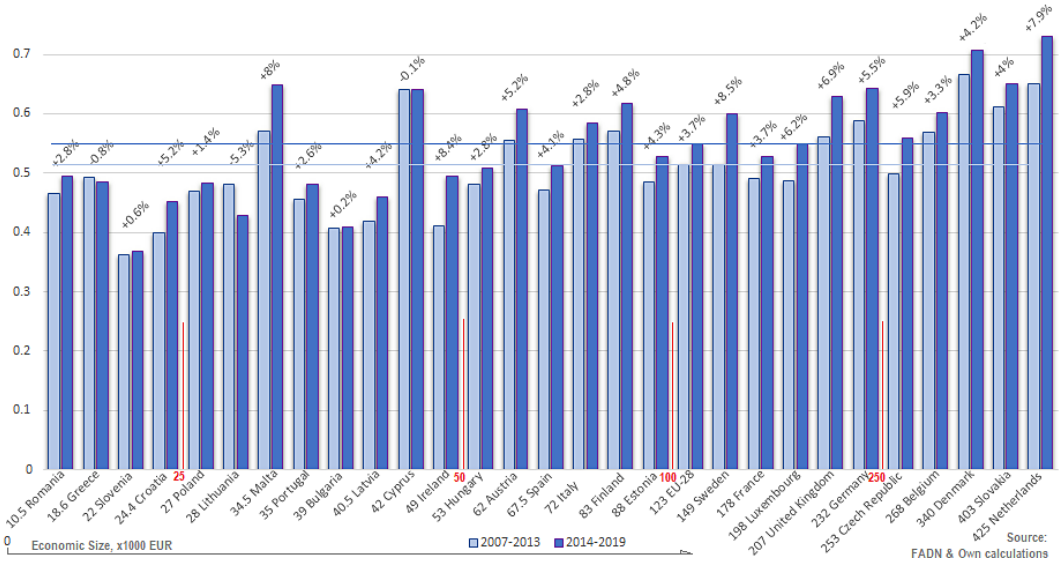

Fig. 1. Composite Economic Sustainability Index

Bulgarian agriculture slowdown is opposed by a sharp increase of labour productivity. Altogether, the economic performance in terms of observed indicators show a decline of all other indicators in the economic pillar encountered by 314% economic size increase. The economic size enhancement leads eventually to a reduction of more than 530 thousand farms in less than 20 years (Ministry of Agriculture, 2003; 2020). According to Ivanov (2020) the low levels of production are due to the weaknesses of the industry, where subsidies incite farmers to have a behavior pursuing economic optimization rather than profit maximization, which to some extent implies why economic indicators in Bulgarian farms worsen through the years.

Lithuanian farms have a vast drop in terms of profitability which fundaments are laying on a worsening of the economic microclimate during the second CAP implementation which costs the biggest economic collapse in the EU agriculture.

The half of medium-big farms are also below the average. Austria, Italy and Finland succeeded to keep their farms above the rising European average powered by the capital productivity and the economic resilience. Estonian holdings have fluctuating economic performance demonstrating boosted labour productivity (+60%) on account of severely decreasing profitability (-67.7%). The farms in Hungary and Spain also gained quite an increase which is supported by good results of the most of the inspected indicators but still below the EU level.

4 out of 5 big farms gain above the EU results, France could not reach the reference values, because actually it is very high, while Luxembourg did it during the second program period. These farms enterprises are acting like a non-farm companies which represent a neo-classical economic performance where every drop is followed by an upgrade of each previous peak – Germany, France, Luxembourg and Sweden. The UK have the only farms gaining a constant economic growth during the whole period without any interruption. All the members of the group perform better in terms of economic environment and labour productivity as well as all the Member States of the biggest farm representatives.

All of these corporate farms are above the average line, Czech Republic joined after better performance in all of the indicators during the second program period. Denmark and Slovakia made an insensible diversification lowering while improving the rest of parameters like the Netherlands where the only bad value is the capital productivity (-13%).

Social pillar

11 out of 12 MS (small and small-medium) have a Social Index below the EU average, where the biggest holdings in Ireland make the exception (Figure 2).

Forced by an inflation based growth of the worker remunerations, the social sustainability is rising almost all over the EU. Greece and Cyprus could not gain a progress and this is due to declining share of the own cultivated land and farmhouse consumption.

The mismatch between them is the decreasing family income in the island country while the continental one has

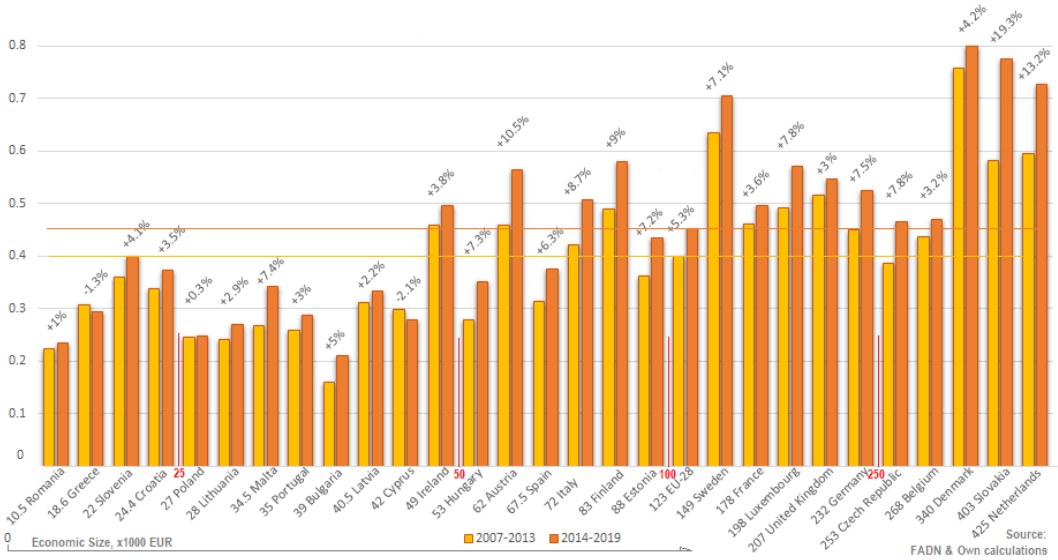

Fig. 2. Composite Social Sustainability Index

stagnation in the own made factors of production. The last one combined with the internal consumption are also causing Poland a lack of growth.

The only one from the Member States with economic size up to 50-thousand-euro Standard Output scoring above the average is Ireland where family income, salaries and the share of own land are at notable levels, which is also common to Slovenian where the social sustainability level become equal to the reference from the first observed period. The rest in this groups continue to rise slowly but far below the EU rate where Bulgarian holdings stay on the bottom.

From the medium-big EU holdings, just like in the Economic Pillar – Hungary, Spain and Estonia stay below the average mainly because of fall behind in the farm salaries. Exactly the opposite is the trend in this indicator of the other members which combined with the high percentage of own land boosts socially the farms in Austria, Italy and Finland.

In the big and corporate farm enterprises the results are above the reference but Belgium and the Czech Republic joined after the second program period. The potential to keep a sufficient amount of labour – experts and workers is the main social difference between the farms in terms of their size.

Ecological Pillar

Ecological winners of CAP implementation are the Baltic countries where the index is enlarged +17% – 23% all the inspected indicators are at sufficient levels. However, their common trend concerning the main detrimental inputs are worsening. However, Figure 3 is exposing a little exaggerated values that also contain the rate of inflation and the paid amounts are higher: for fertilizers (+25-30%), for pesticides (about +50%).

Slovakia, Sweden and the United Kingdom (where only the pesticide costs are higher than the average) demonstrate stable and top levels of Ecological Sustainability as the opposite of the highly increasing above the average indexes such as Poland, Finland and Denmark with improved energy intensity and crop rotations and good levels of pesticide costs. The remaining above EU average MS are Spain, France and the Czech Republic covered by low energy intensity and stocking density. These indicators also help Greece (-1.6%), Bulgaria (+7.3%) and Germany (+3.7%) to take their places between the two reference lines.

From the other side – Croatia has negligible areas for nitro-fixing crops which is very common to Malta and the Netherlands where are situated the most energy intensive productions, the highest fertilizer and pesticide costs and the most intensive animal breading.

The most energy and input intensive production lines are Cyprus and Belgium, where the stocking density is also very high. Ireland, Italy and Germany have very high levels of pesticide and fertilizer usage. Slovenia, Croatia and Hungary did not put enough efforts to include the protein crops in their crop rotation. Austria and Romania are getting very close to the reference and share common trend of sufficient free grazing area for the animals, low levels of energy intensity, fertilizer and pesticide usage.

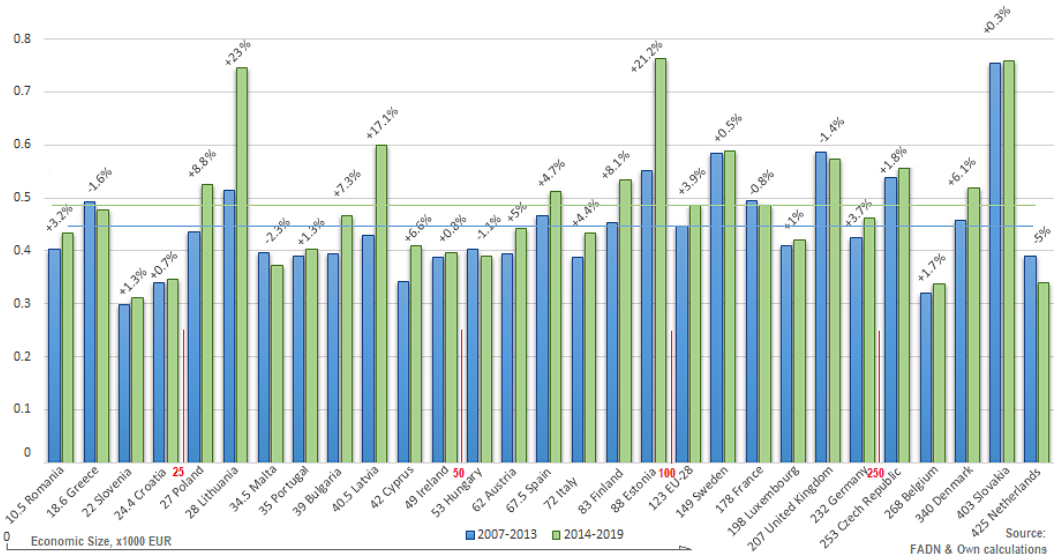

Fig. 3. Composite Ecological Sustainability Index

Compound Sustainability

The economic and social forces are driving and viable factors to small scale farms' Composite Sustainability Index remains relatively at low levels. Romania and Croatia manage to go over the average line of 0.5 which seems whereas Slovenia, Bulgaria and Portugal demonstrating the lowest sustainability scores in this assessment regardless they show some increases (Figure 4).

Poland and Ireland have improved composite sustainability due to respectfully ecological and social pillar. Greece is discerned as a member states where farms declining in every sustainability aspect, but Cyprus holdings share this only in socio-economic field – the ecological pillar gains enough to refer positive in the total index while the trend in the economic one has only 0,1 percentage change and ranks on a top level. This dimensions also prop up Malta results above the EU average. Lithuania and almost Latvia) are part of higher EU half because of their green policy implementation.

Hungary and Spain share sustainability rates under the average with insufficient economic power while the other

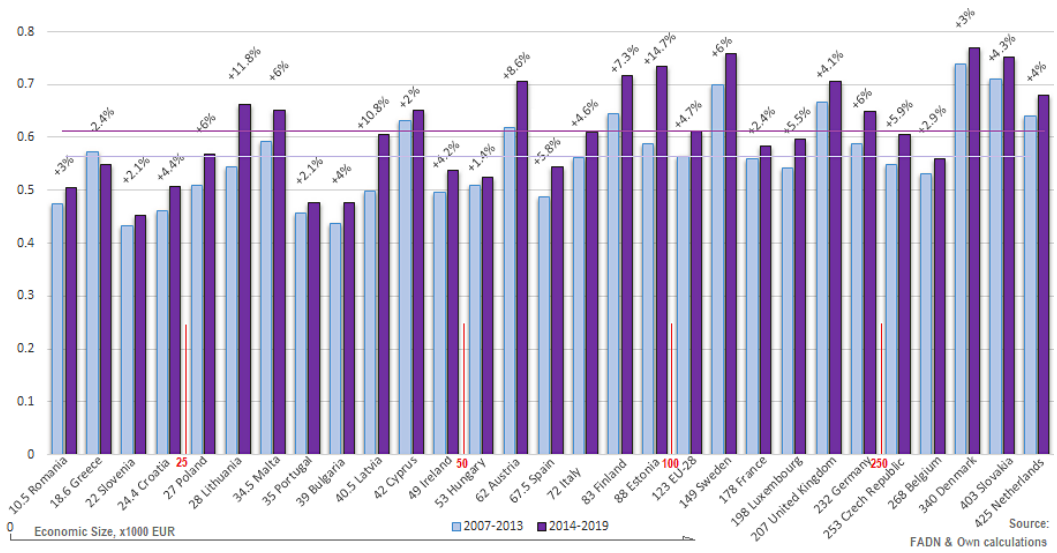

Fig. 4. Total Composite Sustainability Index

medium-big holdings use it to strengthen their ability to perform very well.

The sustainability results in the European Union seems to be very high, enough to see France, Belgium and Luxembourg (three of the founding Member States) under the reference line. All the other big and corporate farms demonstrate the power of their economic size to realize the large scale economies and to invest in the social capital while not all of them succeed to prevent sufficiently the natural resources and might cost a severe damage to the biodiversity.

Conclusions

That composite index is built based on comparative approach and the index is not classified to the degree to interpret in a detail and more particular and sheer way what are sustainability results of EU agricultural farms. It is found out that almost all of the MS gain an increase of the sustainability indices and there are such holdings where all the pillars have high level – UK, Slovakia and the Scandinavian countries.

The small scale farms covered in the FADN turn out not to be the most vulnerable in the EU. Keeping in mind most of them are managed by self-employed owners, part of them are estimated as well efficient and quite sustainable. However, the most vulnerable are situated in Slovenia (small group), Bulgaria (medium-small) and Hungary (medium-big). All factors for sustainable development are depending on the structure and farm management, but on the other hand the public policy continues to play the crucial role for the CAP implementation.

The CAP improves the economic performance of farms to a great extent but at the same time affects their resilience to be vibrant for future and without subsidies. The dependence on economic size cannot be precisely established but is easily understandable the larger is certain farm, the easier is to achieve better sustainability outcomes in terms of good economic performance, good social welfare and better chances for ecological adaptation.

The two different approaches for assessment of sustainability in this article allow to deploys different methodologies leading to expectations to get a more comprehensive and relevant evaluation and outcome. However, some cases need deeper expert interpretation in order specific situation and causal relationships to be identified and explained.

The economic size could not be a benchmark defining the sustainability, but the investment activity, the management quality and land potential need to be analyzed in deeper details.

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