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AGRICULTURAL LAND FERTILITY AND THE RISKS TO AGRICULTURAL SUSTAINABILITY: A CASE STUDY FROM ALBANIA

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ABSTRACT

In the current environment, intentional agricultural intensification without adequate soil fertility recovery could jeopardize agriculture's sustainability, especially in nations like Albania where the sector continues to dominate the national economy. In order to prevent soil degradation, it is helpful to assess the amount of plant nutrient depletion from soils for future planning and recovery. The nutrient-balance approaches, which are based on best practices, are tools for providing indicators of the sustainability of agriculture. The purpose of this study was to assess the nutrient balances (nitrogen, phosphorous, and potassium) in Albania's arable land. Over an 11-year period, the nutrient balances for 12 major agricultural plants were determined using the soil surface nutrient balance method developed by the Organization for Economic Co-operation and Development (OECD). Mineral fertilizer, organic fertilizer, atmospheric deposition, and biological N fixation were among the elements that were quantified as inputs. Harvested plant and fodder plant production were among the outputs.

Keywords: nutrients, phosphorous, nitrogen, soil degradation, productivity.

INTRODUCTION

In Albania, agriculture employs 47.8% of the workforce, uses roughly 24.31% of the land, and generates 18.9% of the nation's GDP (MoARD, 2019). According to Shundi (2006), Albania's primary soil types are limestone, mostly found in the mountainous regions, flysch and marls in the middle region, and fertile alluvial soils along the shore. Furthermore, a significant amount of agricultural land is impacted by erosion or at high risk of erosion due to the slope of hilly and, in particular, mountainous areas: 70% of agricultural land erodes at a rate of 30% per year, 20% erodes at a rate of 5% per year, and only 10% of agricultural land is unaffected by this phenomenon (Shundi, 2006). The situation is expected to be complicated within climate change that affects both natural and man-made ecosystems (Shumka et al., 2024). Although the productivity of Albania's primary agricultural and animal output has improved during the transition, it is still below the EU average (Guri et al., 2015). Despite a 34% rise in wheat yield between 2002 and 2016, Albania's yield is still 20% behind the EU27 average (INSTAT 2012; EUROSTAT 2014); the same is true for milk production. Cela et al. (2010) state that Albanian agriculture continues to suffer serious productivity issues. Utilizing agricultural land allows us to produce a variety of goods that can be used as livestock feed, human food, and other uses (Staniszewska, 2017). However, the removal of nutrients—both macro and macronutrients—from the soil occurs concurrently with the intake of agricultural produces. No studies that are truly related to this topic have been conducted for a long time. Although the goal of soil fertility studies is to combine the fundamental ideas of biology, chemistry, and physics, the results typically result in distinct interpretations of the facts pertaining to plants and soil. Less than 180 meters is the average elevation of the plane lands, which make about 24% of the total land area (MAFCP, 2011; Esubalew et al., 2023). These regions are known for their scorching summers and moderate winters, with an average temperature of 9.8 °C in January. Although there is 800–1,000 mm of rainfall annually, it is not split equally between the winter and summer (only 10% of the rain falls during the summer). The average yields of the major agricultural products have grown over the past ten years, according to data and sources, although they are still below the EU average (Volk and Rednak, 2010; Guri et al 2015). The second decade of the democratic "era," from 2000 to 2008, saw a 33% increase in the average wheat production and a 2.5-fold increase in the average milk yield. Other agricultural products (vegetables, apples, stone fruit, olives, cattle meat, etc.) showed the same pattern. (Marku and Cela, 2010). As a foundation for sustainable plant nutrition management, the goal of this study is to ascertain the balance of plant nutrients such as potassium, phosphorus, and nitrogen in Albania's arable land.

MATERIAL AND METHODS

Secondary data on Albanian agricultural fertilizers and plant output served as the foundation for this study. The Ministry of Agriculture, Food, Water Management, and Consumer Protection's Statistical Yearbook 2009-2019 and INSTAT (2009-2019) served as the information sources. i) The amount of land planted for each plant; ii) Crop yield; iii) Production per plant; iv) The biological need for each plant (N, P, and K); v) The amount of chemical fertilizers used; vi) The amount of organic fertilizers used; vii) Atmospheric deposition; and viii Biological N fixation are the primary indicators referred to at national statistics for this study.
Twelve plants-wheat, maize, rye, barley, trash, vegetables, potatoes, dry beans, tobacco, sunflower, soy, and fodder-are included in our study. We excluded several plants from our study, such as sugar beet, medicinal herbs, and strawberries, for two major reasons: the plants' tiny surface area and the fact that they vary much from year to year, as well as the lack of data for our study's ten consecutive years (2009–2019).

The OECD soil surface nutrient balance method was adopted for this study (OECD, 2001). For the calculation of the nutrient balance (NB-NPK) we used the following equation:

$$NB\ (NPK) = \sum Inputs\ (NPK) - \sum Outputs\ (NPK)$$

where:
NB = Nutrient balance
$\sum I$ = sum of inputs
$\sum L$ = sum of outputs

Nutrient inputs (NPK, tons) = NPK-mineral fertilizer + NPK-organic fertilizers + atmospheric N deposition + biological N fixation. NPK from mineral fertilizers (ton) = Mineral fertilizers used (ton)*Mineral fertilizer NPK content (%). NPK from organic fertilizers (ton)= = Organic fertilizers used (ton) *Organic fertilizer NPK content (%).
Nutrient outputs (NPK, tons) = harvested plant productions + fodder plant productions. Amount of NPK removed by the harvest into the plant (i) (kg)=plant (i) area (ha)*yield of plant (i) (ton of fresh-matter/ha)*NPK coefficient in harvested plant (i) (kg NPK/ton of fresh-matter). Amount of NPK removed by the harvest into the plants (kg)=Σ(amount of NPK removed for each harvested crop) (kg NPK).
Amount of NPK removed by the harvest and grazing of fodder plants (i) (kg)=fodder plant (i) area (ha)*yield of fodder plant (i) (ton of fresh-matter/ha)*NPK coefficient in harvested fodder plant (i) (kg NPK/ton of fresh-matter). Amount of NPK removed by the harvest and grazing of fodder plants (kg)=Σ(amount of NPK removed for each harvested fodder plant) (kg NPK).

NPK balances per hectare of arable land (kg/ha) = NPK balances (tons NPK) / total area of arable land (ha).

RESULTS

The Ministry of Agriculture, Food, Water Management, and Consumer Protection's Statistical Yearbook 2009-2019 and INSTAT (2009-2019) are the primary sources of Albania's statistical agricultural statistics. Table 1 shows the production of arable land.

Table 1. Average production (ton) for the period 2009-2019.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	11 years	Average
Wheat	29162	32713	43188	47544	46234	41612	44067	45413	47215	48937	50237	476322	47632.2
Maize	244912	265061	361996	366352	359874	372000	380000	380000	379714	381059	391104	3882072	388207.2
Rye	3144	2177	2335	3407	3142	2883	3070	3000	2712	2695	2250	30815	3081.5
Barley	3589	4510	7258	8707	6548	6974	7300	7033	9000	9035	9655	79609	7960.9
Oats	21802	25013	27313	29851	27013	27000	30000	30482	31973	34068	34893	319408	31940.8
Vegetables	715405	729904	860445	890193	914022	924000	950000	1030000	1129101	1151928	1166283	10461281	1046128.1
Potato	190007	199988	208017	230148	232956	236747	240000	245000	238345	249804	254543	2525555	252555.5
Dry beans	21836	22970	23953	25257	27210	28000	30000	28000	24859	21200	24542	277827	27782.7
Tobacco	1343	1550	1700	1869	2003	2499	2992	2153	1825	1338	1693	20965	2096.5
Sunflower	2161	2284	2649	3045	2369	1538	2000	2000	1972	1117	846	21981	2198.1
Soya	556	493	477	563	449	341	351	520	664	500	744	5658	565.8
Forage	5333000	5326000	5429000	5900000	5949845	6048000	6100000	6000000	6143688	6688609	7050105	65968247	6596824.7

Source: INSTAT and Ministry of Agriculture statistical data 2009-2019

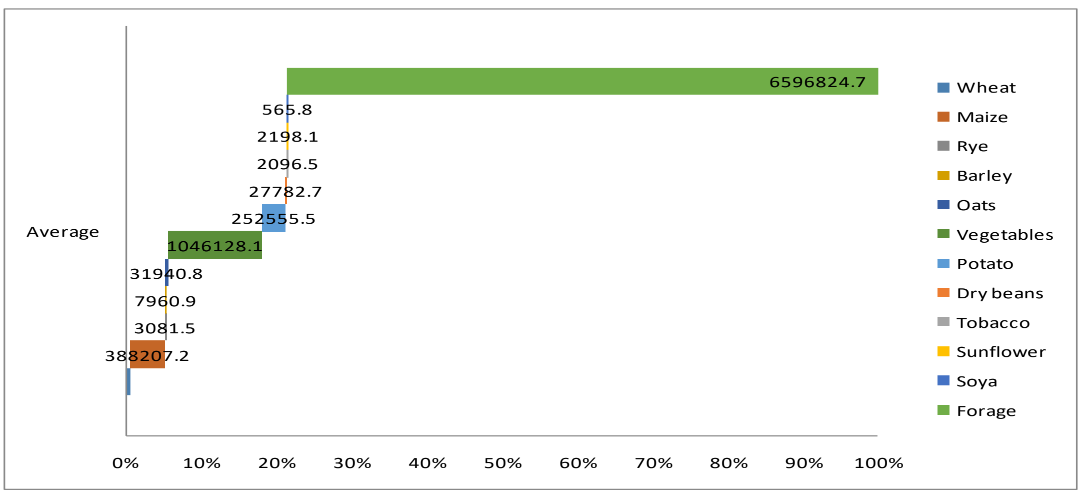

Figure 1. Average production (ton) for the period 2009-2019.

The average annual output of wheat is 47632.2 tons, whereas the average annual production of fodder is 6596824.7 tons, according to the statistics shown in Table 1. It is noteworthy that feed plants are grown on half of the arable land, which makes the cattle industry even more significant. The overall harvest shift between 2000 and 2019 (Figure 1) demonstrates that fodder crops, particularly wheat, have supplanted grains for almost 12 years. Over the same time period, imports of wheat have risen considerably (INSTAT 2020; MBUMK 2012).

Table 2. Yield (q/ha) for the period 2009-2019.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	10 years	Average
Wheat	49.3	55.7	65.1	67	69.5	66.1	69.1	69.8	69.1	68.7	67.3	716.7	71.67
Maize	50	55.6	52.7	51.7	56.1	66.3	65.2	65	65	61.1	65.1	653.8	65.38
Rye	22.7	20.3	21.6	22.8	23.7	23.3	22.3	22.8	22.5	22.7	23.1	247.8	24.78
Barley	24.7	27.1	28.6	30.6	26.7	27.4	27	28.1	29	29.5	28.4	307.1	30.71
Oats	15.7	19.3	19.6	23.1	21.5	19.8	21.3	20.9	21.7	22.1	21.1	226.1	22.61
Vegetables	241.8	240.7	252	266	265	256	263.6	278.3	288.6	287	289.2	2928.2	292.82
Potato	194.9	220.7	231	243.4	238.6	248	244.1	237.2	224.2	234.8	243.9	2560.8	256.08
Dry beans	15.3	16.4	17.5	17.5	18.6	19.7	20.5	17.9	17.5	16.1	16.1	193.1	19.31
Tobacco	12.2	13.4	14.8	15.9	15.1	15.1	20.2	17.3	16.8	15.5	16.9	173.2	17.32
Sunflower	16	19.3	20.3	20.5	16.7	19.6	29.2	29.6	29	22.2	22.8	245.2	24.52
Soya	18.9	19.1	18.2	18.5	16.1	16.1	16.9	22.6	24.9	22	28.3	221.6	22.16
Forage	244	252	263	262	259	258.9	267	267	294.5	310.1	312.6	2990.1	299.01

Source: INSTAT and Ministry of Agriculture statistical data 2009-2019

According to official MoARD (2019) data, there are 413, 971 hectares of total cultivated land (Table 3). However, only 24% of the land area is made up of agricultural land, or approximately 700,000 hectares; 54% is made up of forests, meadows, pastures, etc., and the remaining 22% is used for other purposes (such as urban areas). Albania ranks 120th out of 220 countries in the world due to its low agricultural area per person (only 0.370 hectares per person) (FAO, 2020). Rural households possess the majority of agricultural land (80% of the total agricultural area, or 562 000 ha), with the state owning the remaining 134,000 ha (3 MoARD, 2019).

Table 3. Arable land (ha) in Albania, 2009-2019.

Plant	Cultivated area 2019
Wheat	65,072
Maize	54,115
Rye	976
Barley	3,397
Oats	16,550
Vegetables	31,689
Potatoes	9,726
White bean	13,373
Tobacco	1,004
Sunflower	371
Soya	253
Forage	217,446
Total	413,971

Note: data are for the year 2019 (not average of 10 years of the study).

For the main agricultural plants, the values of biological requirements for macro-nutrients (NPK) are presented in Table 4. These values were extracted from Kadiu & Maci (2009).

Table 4. Average yield by plants and nutrient requirements NPK.

Plant	Average production/year	Average Yield/year	Nutrient requirements (kg/ton production)		
			N	P	K
Wheat	47632.2	71.67	33	12	22
Maize	388207.2	65.38	30	10	28
Rye	3081.5	24.78	30	11	20
Barley	7960.9	30.71	26	11	26
Oats	31940.8	22.61	30	11	20
Vegetables	1046128.1	292.82	4	1.3	4
Potato	252555.5	256.08	5	2	14
Dry beans	27782.7	19.31	36.5	4,2	27,2
Tobacco	2096.5	17.32	41	15	70
Sunflower	2198.1	24.52	33	21	35
Soya	565.8	22.16	79	4.2	34
Forage	6596824.7	299.01	3.5	1.2	2.3

Source: INSTA, 2009-2019; Kadiu & Maci, 2009.

Based on the data shown above: total yield (as 10 years average) obtained from plants cultivated: Wheat; Maize; Rye; Barley; Trash; Vegetables; Potato; Dry beans; Tobacco; Sunflower; Soya; Forage crops and plant nutrient requirement for the unit of production, we have calculated the data at the following table:

Table 5. The amount of nutrients leaving the soil through production NPK/year.

Plant	Nutrient requirements (kg/ton production)		
	N	P	K
Wheat	1571.9	571.6	1047.9
Maize	11646.2	3882.1	10869.8
Rye	92.4	33.9	61.6
Barley	207.0	87.6	207.0
Oats	958.2	351.3	638.8
Vegetables	4184.5	1360.0	4184.5
Potato	1262.8	505.1	3535.8
Dry beans	1014.1	116.7	755.7
Tobacco	86.0	31.4	146.8
Sunflower	72.5	46.2	76.9
Soya	44.7	2.4	19.2
Forage	23088.9	7916.2	15172.7

As can be seen from the table above, the largest losses of nutrients come from production. The largest losses belong to the macro nutrient N, while the smaller losses are to phosphorus.

The main sources of macronutrient inputs to agricultural land are known and consist mainly of: used chemical fertilizers as well as organic fertilizers. Fuerther on the natural fertilizers that containing organic materials include manures and composts, animal byproducts (such as bone meal, blood meal, feather meal), and seed meals. Natural fertilizers that are inorganic ores include potassium and lime (Batjes, 2002; Moore and Bradley, 2018). They typically release nutrients at a slower rate and over a longer period than synthetic fertilizers because microorganisms are involved in a breakdown and release cycle called mineralization. Moisture, temperature, and the microbial species and populations in the soil affect mineralization. Some water-soluble natural fertilizers, such as fish emulsion, are available when rapid nutrient delivery is desired.The following table shows the annual quantities entering the soil:

Table 6. The amount of nutrients coming to the soil /year.

Source	The added amount (in ton)	Nutrient contains (in %)	The added nutrients (in ton)
Fertilizers			
-Ure	35564	N=46	N=16359.44
-Nitrat	38465	N=34	N=13078.1
-Superfosfat	20085	P=21	P=4217.85
-DAP	24710	N=18 P=47	N=4447.8 P=11613.7
Organic fertilizer	5070000	N=0.4 P=0.2 K=0.6	N=23800 P=11900 K=35700

Table 7. Total nutrients coming to the soil /year (in ton).

Source	N	P	K
Chemical fertilizers	38485.4	16531.5	0
Organic fertilizer	243000	12100	34600
Total	529868	28660.71	34801.18

Based on the data presented in the table 7 it can be seen that the total assessed nutrient values were 529 868, 28660.71 and 34801.18 tons per year respectively for nitrogen phosphorous and potassium.

CONCLUSIONS

The macronutrient flow into the soil is dynamic, and in the context of the study, incomes from soil formation, organic fertilizers, and chemical fertilizers have been considered. Meanwhile, removals have been calculated using two sources: production and erosion. Production was the source of the nutrients that were removed from the soil: N 24.58%, P 36.72%, and K 5.91%. The estimated nutritional balance was negative for N and K and positive for P. This scenario reflects soil enrichment in P and soil depletion in N and K components. However, as the removal flow of this element through the secondary product (straw) was not considered, the positive phosphorus balance should be taken with reserves. Farmers should apply a certain amount of chemical and/or organic fertilizers because of the N and K imbalance. Planting leguminous plants (as prey) is thought to be a significant way to supply plant nutrients, particularly nitrogen. On the other hand, growing leguminous plants minimizes soil erosion, reduces the need for fertilizers, and protects the environment.

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