Installation of drip irrigation system combined with improved varieties

The baseline results compared with the scenario of the combination of improved varieties (SC1a) and drip irrigation (SC1b). Their combination composes the SC1 scenario.

i. Crop Pattern of field crops and land use (BAU)

The initial values of the observed typology were presented in the model and used as a first time simulation. The business-as-usual scenario, indicated that the dominance of crop is not changing. However, there is a drop in the land as the years continue, indicating that at some point the cultivation is not covering the needs, thus the land is abandoned.

Table 10. Mean Crop Pattern of Farm-Types

Mean Crop Pattern	Commercial farms BAU	Livestock farms BAU	Diversified farms BAU	Smallholder farms BAU
sugarcane	1,4	0,05	0	0
wheat	0,43	0,35	0,45	0,36
maize	0,21	0,21	0,34	0,16
clover	0	0,2	0,23	0,11
shorgum	0	0,17	0,1	0
Total	**2,04**	**0,98**	**1,12**	**0,63**

Starting with the sugarcane farms, sugarcane remains the dominant crop. This is due to the contract between farmers and public factories, offering a secure income for farmers. Following that is wheat, that is cultivated, also, due to a small contract, but mostly for cultural reasons. Last, there is some clover that is evident in the farming systems, usually used as a cover crop or for short rotations. Livestock farms have wheat as their dominant crop, which, in some years, is reduced for maize production to be increased.

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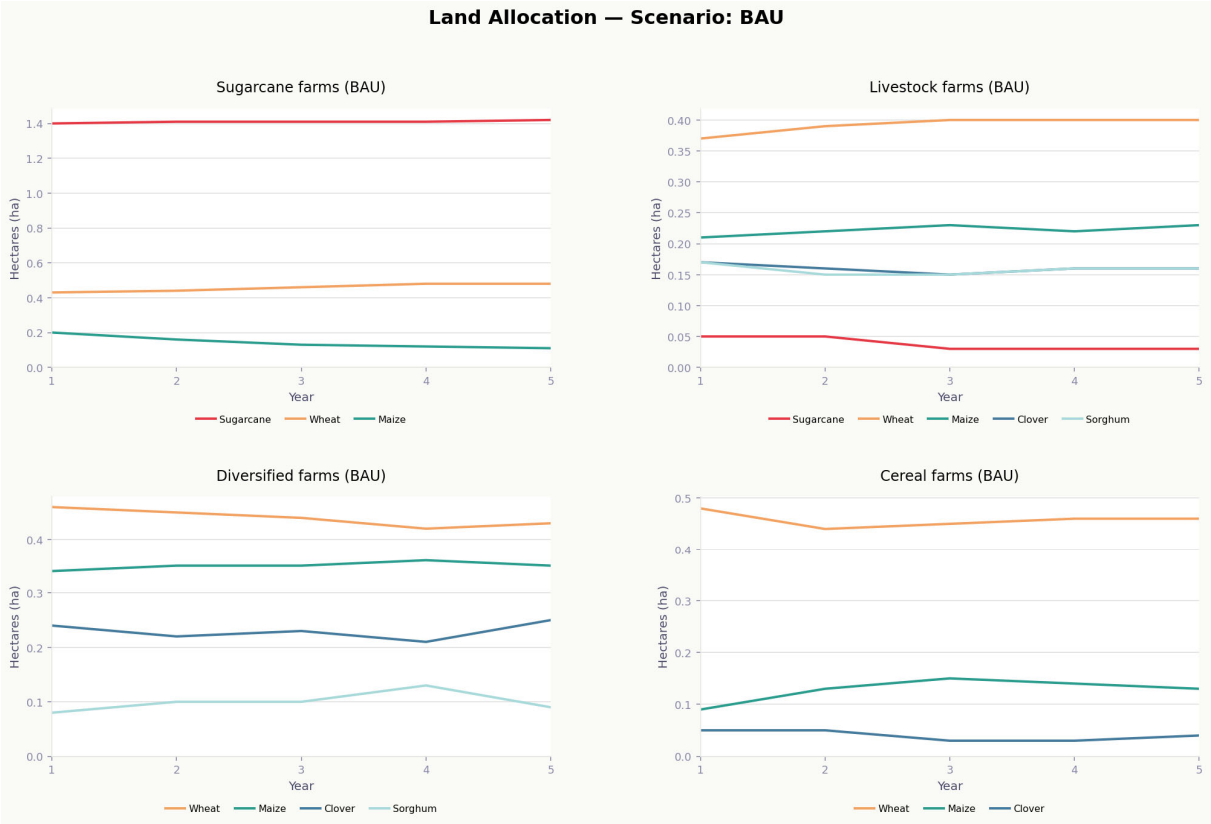
Figure 13. Crop Pattern per farm-type



However, maize is never cultivated more than wheat. Clover and sorghum present a constant cultivation land. This is because farmers choose to grow them in a dedicated plot as feed for their livestock. Diversified farmers cultivate a mix of crops in their fields. Wheat is presented as a dominant crop, followed by maize. However, maize never becomes the primary crop. Among sorghum and clover, the two crops are cultivated in relatively stable amounts of land, with small changes for the third and fourth place. Finally, the smallholder farmers are cultivating mainly wheat. This has the most land allocated, followed by maize. Clover is also evident in small share of land. The cultivation is aiming for a small rotation in systems but is not always cultivated.

i. Crop Pattern (SC1a, SC1b and SC1)

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The first scenario that was tested for the area of the Living Lab was the combination of improved varieties and drip irrigation. These varieties include an improved variety of wheat and maize. Their characteristics include an increase in yield by 20%, less yield variability (-15%) and better nitrogen absorption. However, this is coupled with an increase of 15% in input costs and increased labor costs.

In order to better understand the importance on the combination of agroecological interventions, two pre-scenarios were tested first. These included the use of only improved varieties (SC1a) and the use of only drip irrigation (SC1b). After that, both of them were combined to yield the final results of scenario 1.

Therefore, starting with the introduction of improved varieties, there were some changes in the land allocation. In the sugarcane farms, sugarcane remains the primary focus of cultivation. However, the land of it at some point is reduced, giving more space to the improved crops to be cultivated. Wheat is the second crop, potentially relating also to its contracting nature. In the livestock farms, wheat dominates with a stable production land with a slight increase. Maize is also cultivated as a fodder and is increased in land. Sorghum and clover, remain evident; however, the new varieties seem to take more space over them. Last, sugarcane is slightly reducing. In the diversified farms, the land for wheat is dropping significantly, but stabilizes over the last years. Maize dominates the systems, taking the land from wheat. Last, the sorghum and clover seem to exchange lands in the land that remains available. In the smallholders' wheat land allocation declines over time, giving its space to maize. This can be driven by the better yields maize achieves in the area, better than the improved wheat. Also, the area of the clover decreases over time Finalizing the first pre-scenario, the model was set back to each baseline form. After that, the characteristics of the drip irrigation (second pre-scenario), were introduced. This included a 30% increase in yields and a reduction of 40% in water use. Also, it included the cost of installation. As it was expected, the land allocation was again affected.

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Figure 14. Crop Pattern Scenario 1a

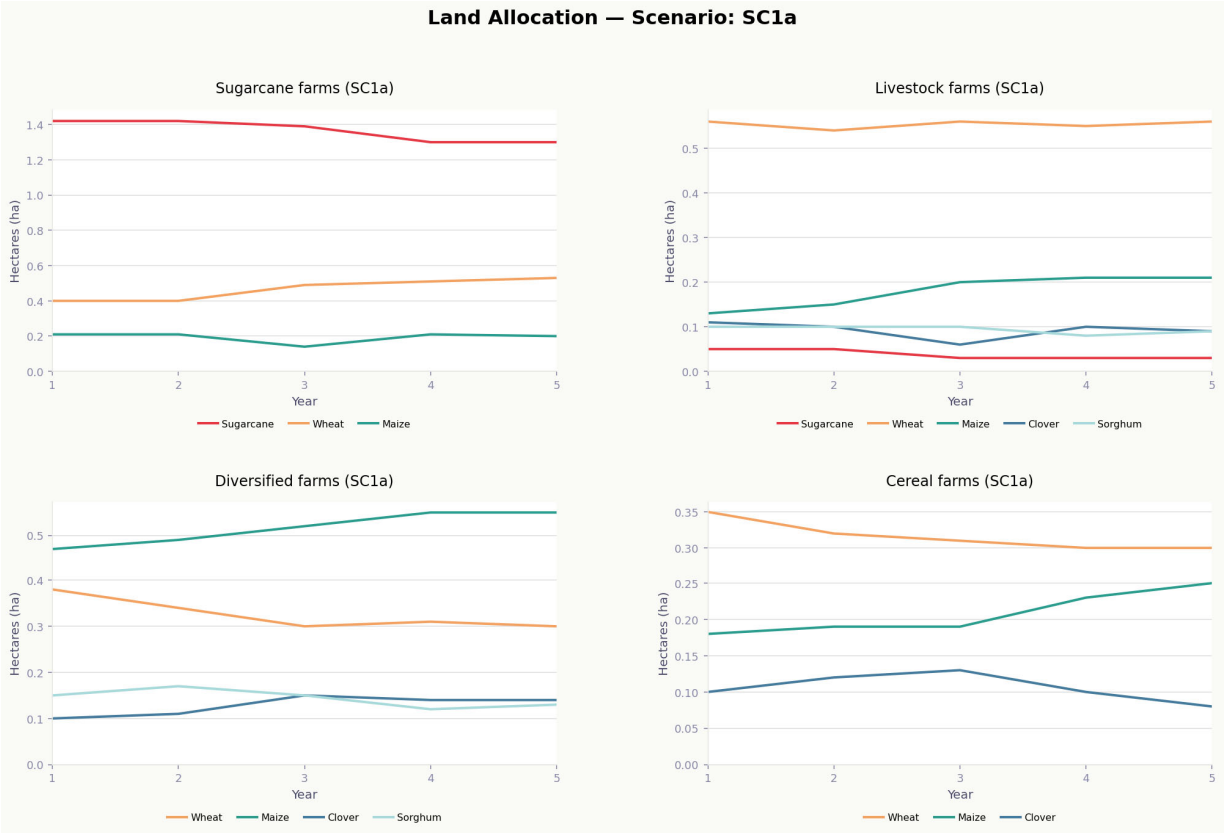

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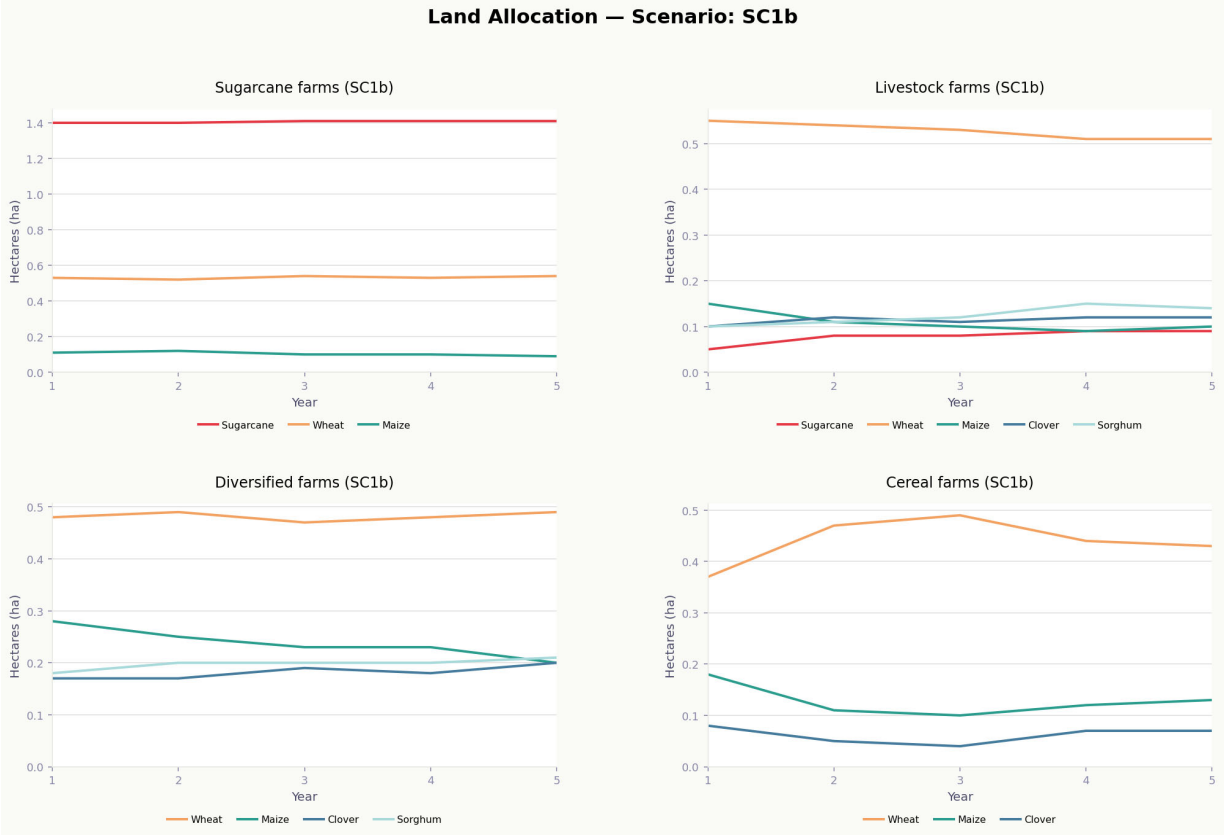
Figure 15. Crop Pattern Scenario 1b



In the sugarcane farms, sugarcane has almost the same land allocation as the BAU, due to its profitability. Wheat and maize have a small increase; however, the farmers still prefer to cultivate sugarcane. In the livestock farms, wheat is decreasing over time, potentially from the better allocation of water, which allows space to be freed for other crops to be cultivated. The rest of the crops are remaining stable over the simulation, some with a small increase indicating the intention of forage cultivation. In the diversified farms, wheat presents minor fluctuations over the years but remains the dominant. Also, maize and clover achieve some stability, indicating a better crop mix, due to the new irrigation system. Thus it is safe to note, that drip irrigation, moves the interest over the cultivation of maize and clover. Last, the smallholders, wheat increases a lot until the third year and then stabilizes. Also, maize is decreasing and then stabilizes after the fourth year, while clover gradually decreases. This result indicates that in the most constrained systems, introducing a reliable irrigation system stabilizes the production, without changing the overall allocation of crops.

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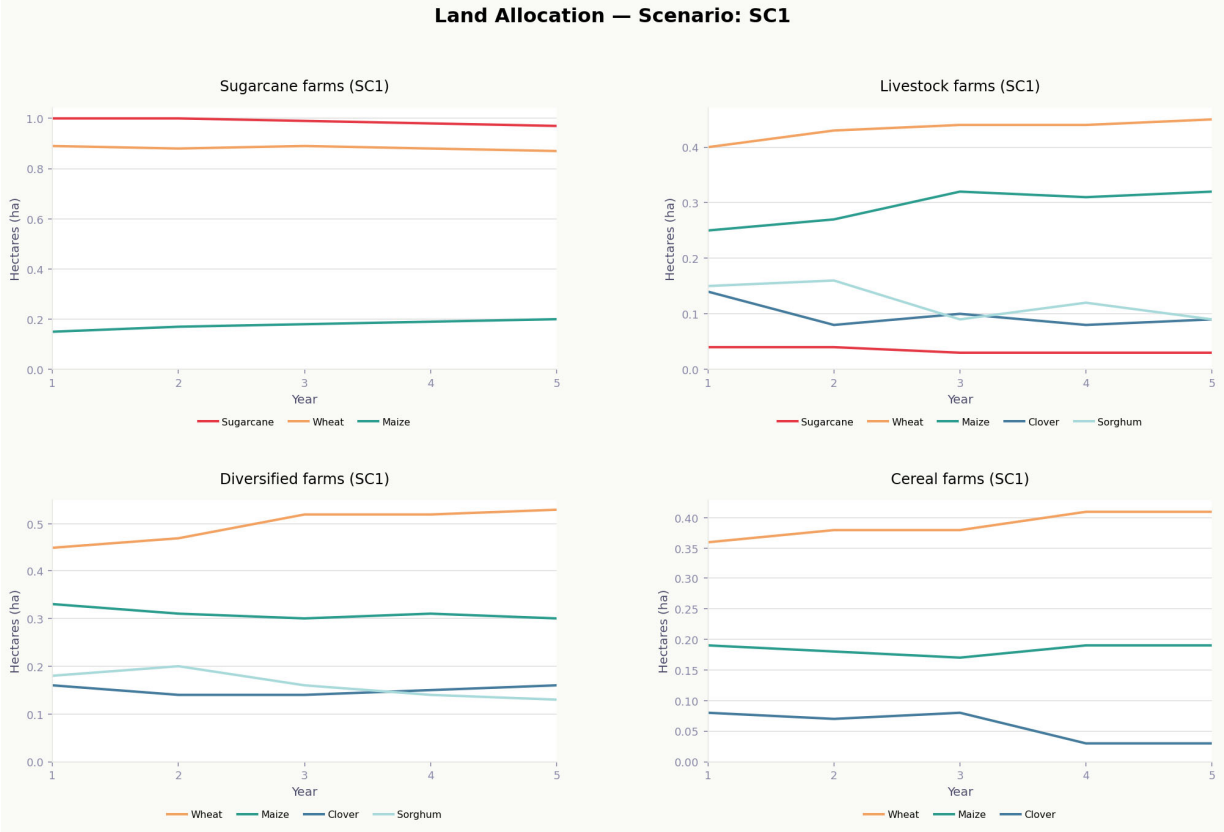
On that note, a separate simulation including both practices was introduced in the model. This combination resulted in an assumed average nature of their characteristics. Thus, the ones added in the model were a total of 25% increase in the yield, a less yield variability (-15%), 40% less water used. On the other hand, the combination included an increase in costs of 30% and a 30% increase in the labor needed.

Figure 16. Crop Pattern Scenario 1



This combination is evident on the crop allocation. Starting with the sugarcane farmers, sugarcane nearly flat, as expected in the contract production. However, there is a substantial allocation also to wheat and maize, as the new varieties offer other potential sources of income. In the livestock farms, wheat experiences a rise over time as does maize too. This is also explained by the potential the new, stable crops have to offer to the farmers. The rest of the crops remain relatively stable, with small fluctuations, indicating a diversity of production in the systems. In the diversified farms, wheat now becomes the dominant crop in the place of maize. This change is due to the potential returns the new wheat variety can offer, due to the contract

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nature of its production. Both see small reductions, indicating a strategic shift toward high-performing improved grains and away from less profitable feed crops. Last on the smallholders, wheat lightly increases or stabilizes over time at the core of the smallholder plot. Maize increases, due to the new irrigation systems and the perks of the improved variety on yields and stability.

ii. Income difference between scenarios

Regarding the revenues (Figure 17), the sugarcane farms scored the highest of all with a total of 973,28 € annually. This is attributed to the cultivation of sugarcane. Next, the livestock farms generate revenues of 755€ annually, with a significant contribution coming from the sales of animal products. After that, the diversified farmers generate an average of 515,36€ annually, due to the selling of surplus products. Last, the smallholders had the smallest average value of 273,94€ annually, which is supported by the small contract nature of wheat and subsidies. Moreover, the introduction of the new varieties (SC1a) appears to positively affect the returns that farmers receive. There is an increase in all the farm types, that is explained by the better yields that are achieved. Also, the stability that they have over their returns it is evident over the moderate stability of the forth and fifth year. The highest revenues are achieved by the sugarcane farms, surpassing their BAU score, while also the smallholders enjoy some gains and alleviation of the economic shocks in the BAU. Similarly, the drip irrigation (SC1b) is almost reaching the ones in the first pre-scenario. It is possible that this is explained by the consistency in yields and water use that the new irrigation system offers, compared to the previous one. Finally, the combination produces the highest and most stable ones compared to the rest. sugarcane farms, where the additive effect is strongest with 18–22% improvement over BAU. Also, there is a reversal of the declining trend in the net returns across the years. Both practices minimize stresses on the crops, achieving high and stable gains. Also, the smallholder and diversified have their highest and most consistent incomes.

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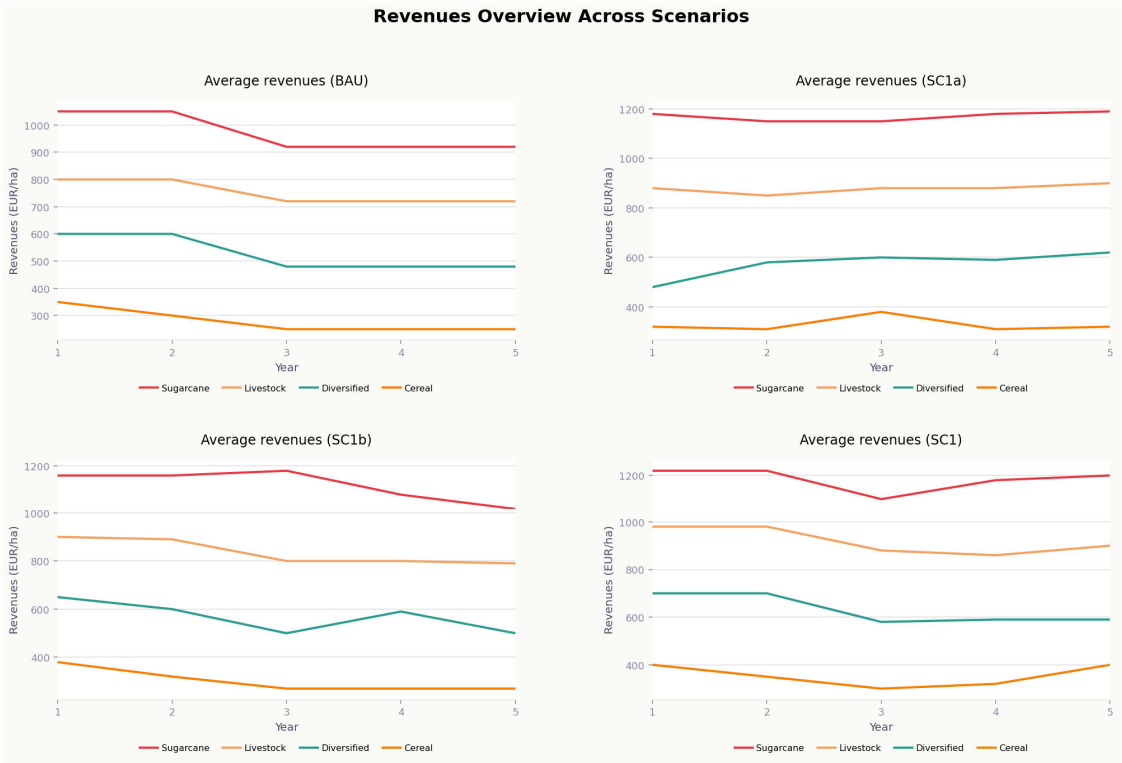
Figure 17. Average revenue per scenario and farm-type



iii. Water use and nitrogen leaching difference between BAU and SC1

There is a high water use among the farms (Figure 18). This is driven by the flood irrigation system that is the main mean of irrigation. The sugarcane farms are the main water users, and consume a large amount, due to their need of high yields. In contrast, the smallholders have a consistent, but low, water use compared to the rest. Adding improved varieties (SC1a), the farms show consistency on the amount they are using. There is a slight drop of 10-15%, which can be explained by the resistance in heat and salinity that the crops achieve. Again, the highest users are the sugarcane farmers. However, adding the drip irrigation characteristics (SC1b), the water use dropped by 30-40 %.Yearly trends are stable, reflecting the efficiency of targeted irrigation. In general, the sugarcane farms experience a great reduction, followed by the rest. The combination offered (SC1) a reduction close to 45-50% over the BAU. The mos affected farms are the sugarcane and livestock ones, while remaining the main water users in the living lab area. The latter also, achieve a stable and minimized use over the total of the five years.

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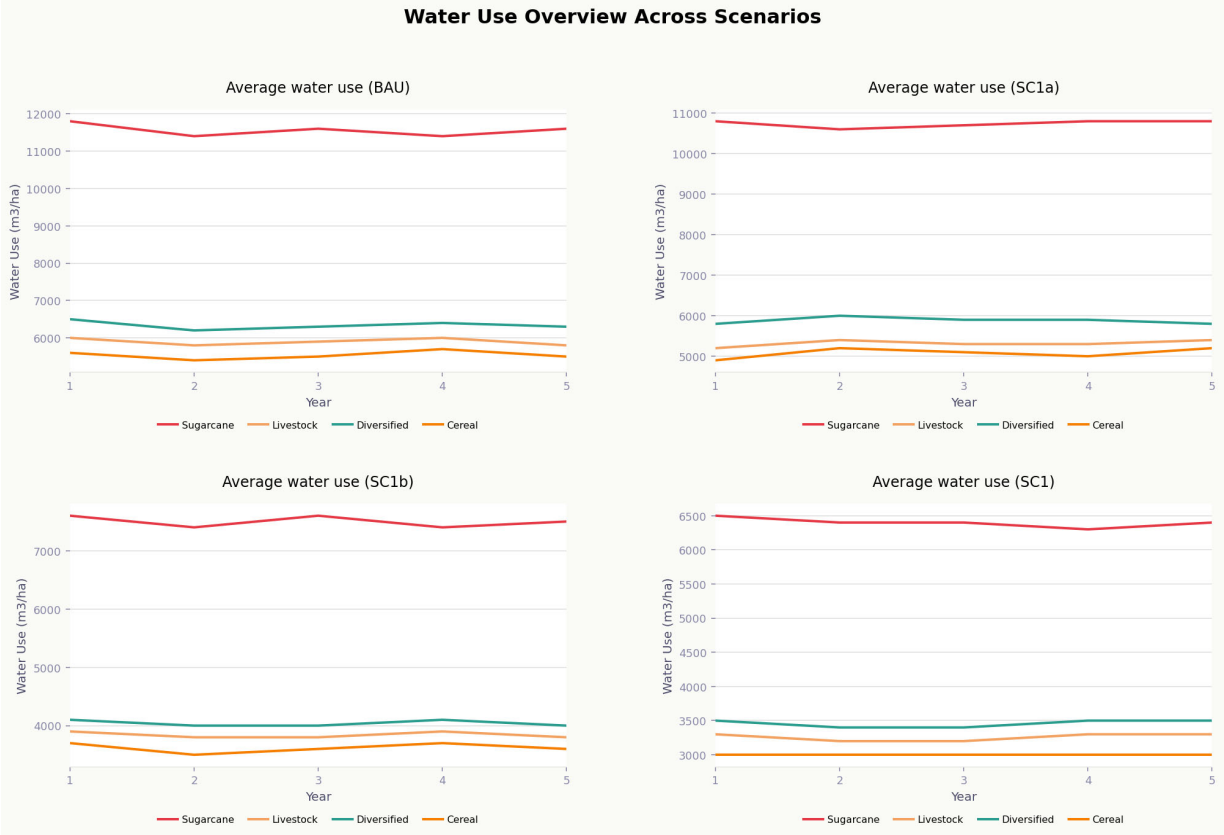
Figure 18. Average Water Use



Regarding the nitrogen leaching, the sugarcane farms seem to cause the most among the rest. This can be expected, due to their aggressive use of fertilizers to assure higher yield, thus better returns. On the other hand, the rest of the representative farms show a modest but almost constant participation in nitrogen leaching. Furthermore, the improved varieties (SC1a) caused a slight increase in all the farm categories. This is to be expected, as the new varieties often require more nutrients to maximize the yields. Even in the case of sugarcane farms, they have the highest score, the increase is not sharp. On the second pre-scenario, drip irrigation (SC1b), evidently affects the nitrogen leaching. The change from flood to drip succeeds in better fertilizer distribution, achieving better absorption, and minimizing wash-off. However, still in the case of sugarcane farms, the decrease is not very evident, due to the high-yields driver. Last, the combination (SC1) of practices achieves better results in general. The leaching is the lowest in contrast to the rest of the pre- and BAU scenarios. Livestock farmers are the most benefited ones, with the least value being the combination in contrast to the single practices.

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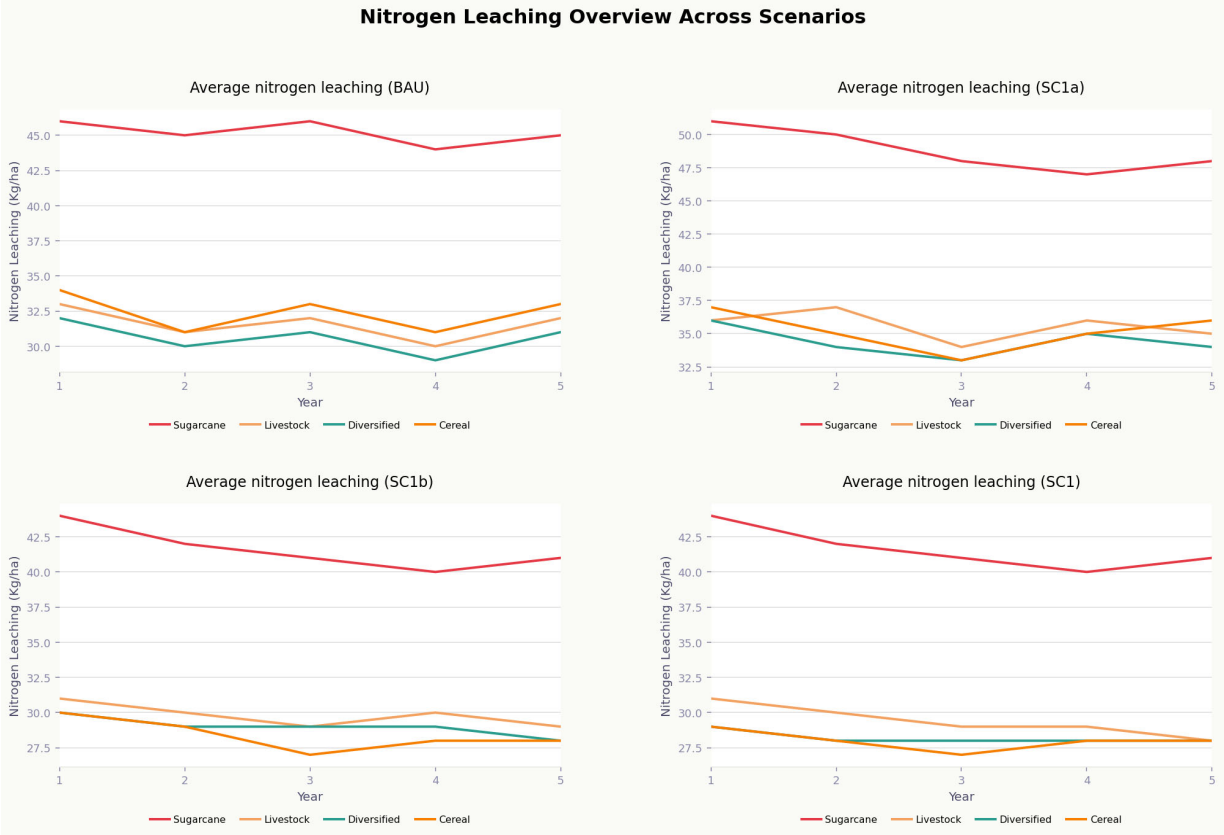
Figure 19. Average Nitrate Leaching



iv. Pesticide use difference between BAU and SC1

The results on the use of pesticides is different among the farm types. The sugarcane and livestock farmers have low use of pesticides in general, while the cereal and diversified farmers see and increased use of them. This can be attributed to the difference in the production goals. While the two former ones focus in selling, the latter are more keen of subsistence, thus they need to conserve their yields. For improved varieties (SC1a), there was a modest decrease in the use of phytosanitary products, in contrast with the BAU. This suggests that the new crops exhibit better resistance to certain local pests. The farm type that benefited the most was the diversified farmers, with a sharp drop after the second year. Also, in drip irrigation (SC1b) the drop on the use of pesticides was less evident in comparison to the BAU. In all cases, there was a reduction in the use of pesticides; however, this was around 7%. Out of all the farm types, cereal had the least reduction. However, it is safe to say that improved water management can lead to a reduction in pesticide use. The combination of practices (SC1) in comparison with the rest showed the greatest reduction of all. This reduction ranged from 10-13 %, with a downward trend over the simulation years. The farm type that was mostly affected was the cereal, with a sharp drop in pesticide use, while the diversified also had a sudden drop

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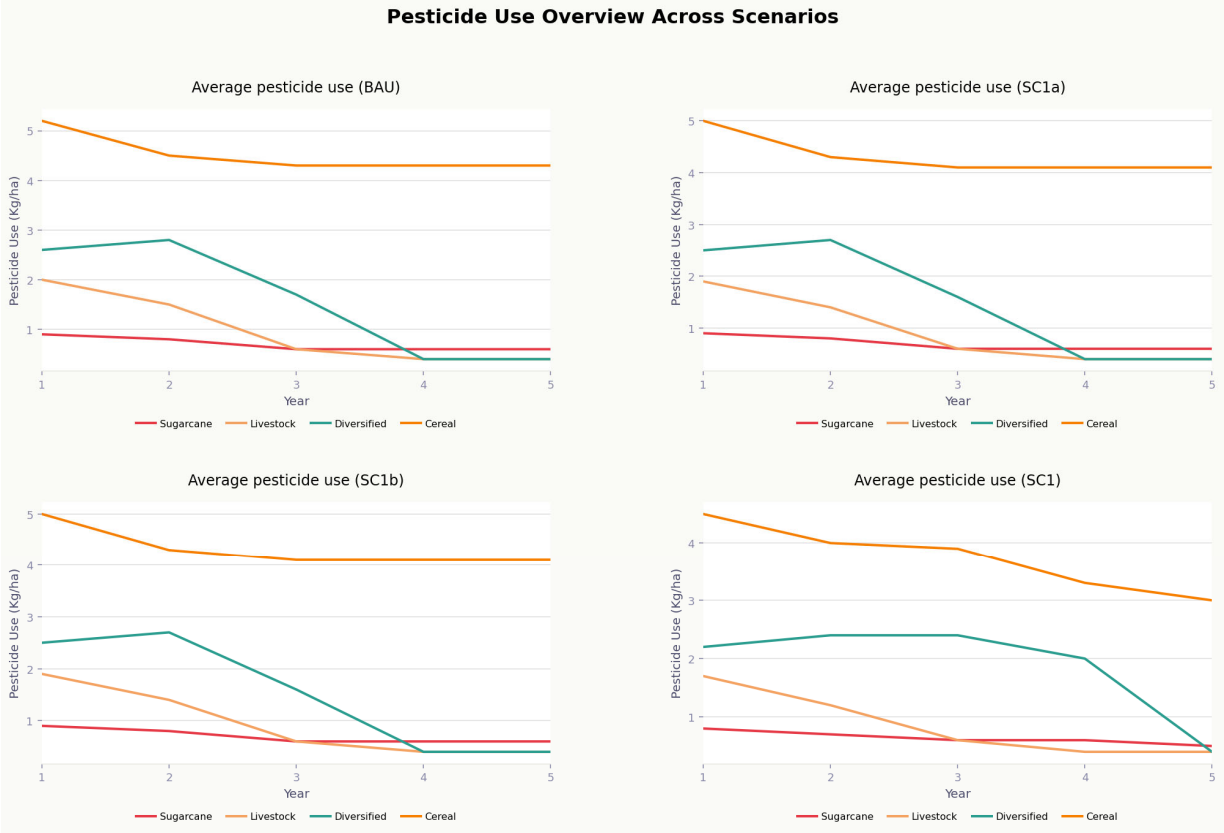
after year 4. This combination of practices can be an indicator of the importance of the combination of agroecological practices in contrast to single interventions.

To conclude, the indicators tested in these preliminary results, showed the potential of the combination of agroecological practices in the area of the Living Lab. However, it is important to note that, extensive care should be given in areas such as costs and labor, that would be better assessed in a later step, to better address their cost and high labor needs for their application.

Figure 20. Average Pesticide Use



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Appendix A. Comparative tables among the different sub-scenarios and scenario.

Table 1 Land allocation changes in each scenario per farm type

Farm type	crop	BAU	SC1a	SC1b	SC1
Sugarcane (FT1)	sugarcane	1,42	1,37	1,41	0,98
	wheat	0,47	0,47	0,54	0,88
	maize	0,15	0,20	0,09	0,18
Livestock (FT2)	sugarcane	0,04	0,03	0,08	0,03
	wheat	0,39	0,55	0,54	0,43
	maize	0,22	0,18	0,11	0,29
	clover	0,17	0,10	0,12	0,10
	shorgum	0,16	0,11	0,13	0,12
Diversified (FT3)	wheat	0,44	0,33	0,49	0,50
	maize	0,35	0,52	0,24	0,31
	clover	0,23	0,13	0,18	0,15
	shorgum	0,10	0,14	0,20	0,16
Cereal (FT4)	wheat	0,46	0,32	0,44	0,39
	maize	0,13	0,21	0,13	0,18
	clover	0,04	0,11	0,06	0,06

Table 2 Changes in selected indicators for each scenario per farm type

Indicator	Type	BAU	SC1a	SC1b	SC1
Total Farm Income (EUR/ha)	Sugarcane	973,28	1167,90	1117,54	1179,68
	Livestock	755,00	873,23	833,15	914,31
	Diversified	515,36	570,23	572,85	628,49
	Cereal	273,94	327,08	300,82	355,60
Water use (m3/ha)	Sugarcane	11480,00	10674,00	7478,00	6322,20
	Livestock	5648,00	5292,00	3670,00	3096,00
	Diversified	6140,00	5844,00	4021,00	3388,00
	Cereal	5440,00	5056,00	3522,00	2980,00
Nitrogen leaching (Kg/ha)	Sugarcane	45,20	48,86	42,03	41,98
	Livestock	32,08	35,48	30,14	29,68
	Diversified	31,08	34,40	29,33	28,26
	Cereal	32,44	35,16	28,55	28,28
Pesticides (Kg/ha)	Sugarcane	0,70	0,67	0,66	0,64
	Livestock	1,00	0,95	0,94	0,87
	Diversified	1,57	1,49	1,46	1,89
	Cereal	4,52	4,29	4,25	3,75

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