PrOPara project
Socio-economic impacts of alternative GIN control practices

Sheep & goat systems in France and Scotland

Project deliverable 11. (WP4)

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1. Introduction

Parasitism is well recognized as a major challenge to the health and welfare of organic livestock. In organic small ruminant production systems, endoparasitic disease is accepted as the most important multifactorial syndrome, resulting in high negative effects on animal health, expressed by a lack of appetite, diarrhoea, anaemia and in extreme cases, by death (Corwin 1997). In organic cattle production, despite the rather low stocking densities and use of improved grazing management practices, helminth infections are still a significant issue.

These may alter the process of production as well as causing a decrease in the production level (meat and/or milk), the quality of feedstock, the daily weight gain and the reproductive rates; thus affecting economic returns (Fourichon, Seegers et al. 1999, Lopes, Nicolino et al. 2015). The economic return is also affected by higher management costs due to drenching, additional labour and the implementation of new techniques (Lopes, Nicolino et al. 2015). These explain why it is necessary to assess economic impacts of animal health management practices (Lopes, Nicolino et al. 2015) and to quantify the expected cost benefit.

Furthermore, since the 1950s, agricultural farms in Europe have changed in nature, from a family type to larger businesses. This shift in the nature of farming implies a greater focus on the economic aspects (Fetrow, Cady et al. 2005). Morris (1969) was a pioneer in applying the concept of marginal cost in veterinary decision-making processes; he placed more emphasis on the economic dimension, arguing that the inputs used for disease control should be increased to the level where the cost of an additional input unit equals the supplementary value generated.

Many economic impacts studies have been conducted in the last decades on animal disease (Bennett 1992, Dijkhuizen, Huirne et al. 1995, Huirne, Dijkhuizen et al. 1997). However, several methods and criteria have been used so far, reflecting the farm system complexity with no straightforward impact pathway as well as the absence of a wide consensus within the scientific community on how to evaluate economic impacts of animal diseases (Lopes, Nicolino et al. 2015). The high complexity of a farm system requires an understanding of the whole system and not only individual components of it, resulting in a complex implementation of impact assessment studies as well as the adoption of appropriate disease control strategies (Howe and McInerney 1987).

Since the profit margin has become more critical in livestock systems in the last decades, it is of utmost importance to better understand drivers of production efficiency in relation to parasite control, in order to take more suitable decisions and optimise profits accordingly (Lopes, Nicolino et al. 2015). This report aims to deal with that challenge by looking at the economic impacts of a selected range of alternative parasite control strategies in small ruminants, namely goats and sheep. The report also looks at the social drivers and barriers to the adoption of alternative practices. The first section presents the methods developed and used. Results are then presented in a second section and the report concludes with a general discussion and conclusion section.

2. General methodology

The methodology is composed of two distinct parts. The first concerns the farm model that was developed to estimate the economic impacts of GIN control practices. The second is on the structured approach developed and implemented during the stakeholder workshops. Results from a survey of organic small ruminant farmers, together with an ex-ante analysis with the farm model are used during workshops, which also address social factors explaining the uptake and acceptance of GIN control practices to control parasites.

2.1 Farm model

A farm model was developed in order to estimate the economic impacts of current and alternative GIN control practices. The farm model was designed to be flexible and allow parameter changes in a live setting such as the workshops. Farm models also allow a relatively low cost method of assessing the potential impacts of management changes. Controlled experimentations provide more detailed results, but require extensive financial and human resources, therefore modelling can help focus research on more promising areas.

The farm model developed and used in this study was constructed in Microsoft Excel (2013), allowing visualisations and flexible data entry. Modelling was restricted to the enterprise level, i.e. sheep or goats, and provided a representation of inputs (specifically, feed, GIN control and labour) and outputs (milk and meat) to generate a gross margin per head figure. The model was specifically adapted to include precise figures for meat and milk withdrawal periods, as well as the ability to estimate production losses from parasitism and variations in labour input.

For each system a typical farm description was provided by the scientific and extension teams in the two focus regions in France and the UK. The typical farms comprised an organic goat system in France (typical in Occitanie and Auvergne-Rhône-Alpes Regions) and two organic sheep systems in Scotland (lowland and upland).

2.2 Workshop approach

A structured workshop approach was adopted to adequately address both the social and economic factors related to adoption of alternative GIN control practices by farmers. To this purpose, we adapted the **Structured Decision Making (SDM)** approach commonly used for decisions taking (Gregory and Keeney 1994, Conroy, Barker et al. 2008, Ogden and Innes 2009, Gregory 2012, Johnson, Eaton et al. 2015, Fatorić and Seekamp 2017).

Although the purpose of this study was not formally about taking decisions, the varying GIN control options for farmers, allows a similar approach to SDM. However, for this purpose the final SDM step on decision taking was not considered and was replaced by a general discussion on possibilities to adopt the different options considered and their drivers as well as on research needs and next plans.

Furthermore, the SDM approach excels in finding and analysing alternatives to current practices, however, it does not address factors on innovation uptake and farmers' acceptance towards those innovations. In order to better address these elements, we complemented our approach with theories on innovation, namely the **theory of innovation diffusion** by Rogers (Rogers 1995) and the **theory of planned behaviour** (Terry, Hogg et al. 1999, Armitage and Conner 2001, Ajzen 2002)**.** These theories have been extensively used empirically to the purpose of innovation assessment (Scott, Plotnikoff et al. 2008, Talukder 2012).

The adapted approach based on SDM is iterative and composed of 8 steps. The structured participatory workshop must involve as least 4 to 6 farmers, 1-2 consultants/extension officers and up to 3 scientists (parasitologist and economist). One of the farmers should also be external to the project to provide a different perspective. More generally, a diversity of views on GIN control practices, sustainability issues and ways of managing farms, must be reached to make the process more reliable and robust. The workshop process comprises:

- First step: rationale and objectives of the workshop

The first step consists of introducing the workshop to the participants and comprises of three key elements, namely (1) the presentation of the objectives to the participants, (2) the exposition of the expected outcomes for participants, and (3) asking feedback from the attendants to clarify points of contention and obtaining agreement on the agenda of the workshop.

- Second step: to define stakeholders' objectives

The second step aims at defining objectives, in the same way as for SDM. The goal is to make clear what "matters" for the participants, what they want to achieve, in order to better consider the alternatives afterwards. For the purpose of this study, the objectives to correspond to the general goals of farmers regarding their business unit (e.g. maximising revenue). These objectives are not necessarily linked to the topic of parasite control (they can be if parasite control is considered as an issue on the farm) but will serve as a basis for further reflections.

This step is structured in a way that examples of objectives are first presented to the attendance, before allowing farmers to think on their objectives and discussing them in a plenary session. These objectives are then sorted to eliminate duplicates, and participants are finally asked to rank them according to their level of importance. This ranking is based on a swing weighting preferences approach (e.g. Jacobs, Dyson, and Stockton 2013), accounting for the number of times each objective is ranked first and converting this into a score of importance (see Table 1).

Objective / Ranking (e.g. with 10 participants and 3 objectives)	1	2	3	Score of importance
Objective 1	0	2	8	0 (0/10)
Objective 2	3	5	2	0.3 (3/10)
Objective 3	8	2	0	0.8 (8/10)

Table 1 Example of table of preferences for objectives

- Third step: To transform objectives into evaluation criteria

The third step consists of defining the criteria (maximum 4 criteria per objective) to measure the level of fulfilment of the objectives. A consensus between participants is not necessary here; but each farmer should reflect on his/her own criteria of importance, which will form the basis for comparing performance of different GIN control practices.

- Fourth step: To identify alternatives and tackle social factors

In each workshop, the organizers present up to five alternative GIN controls, in accordance with results from the general survey; but farmers have the opportunity to comment on these alternatives and identify other ones they consider important in relation to their objectives and evaluation criteria.

Then, in order to tackle social factors explaining the uptake and acceptance of alternative practices to control parasites, farmers are asked to fill out a short questionnaire. The alternatives addressed are different depending on the system considered (goat or sheep) and the region or country targeted:

- Goat system in France:
    - The Targeted Treatments (TT) and Targeted Selected Treatments (TST) procedures;
    - The strategic use of anthelminthic treatments (Eprinomectin in combination with Levamisole);
    - The non-access to pasture for kids (up to one year old);
    - Changes in the pasture system (in general);
    - The use of bioactive plants (including the use of Sainfoin).

- Sheep system in Scotland:
    - Reduced stocking rate
    - Drenching part of the flock e.g. more susceptible groups
    - Targeted selected treatment e.g. individual assessment & treatment
    - Increased protein
    - Bioactive feeds e.g. Sainfoin, chicory

The questionnaire comprises closed questions, mainly based on a Likert scale (Brown, 2010). The Likert scale used is as follows: strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree. Table 2 specifies the questions addressed, which apply for the five alternative practices mentioned above.

N°	Question	Possible answer
1	When thinking about the relative advantage of these different practices, do you think that they are more effective than your current practices or past practices (if the practice has already been adopted)?	Based on the Likert scale
	Please also specify whether you adopted or not these different practices	Yes/No
	If you already adopted these practices, would you say that your decision was influenced by the surrounding social context (neighbours who already adopted, etc)?	Based on the Likert scale
2	When thinking about these different practices, would you say that they are in line with your personal beliefs and values?	Based on the Likert scale
3	When thinking about these different practices, would you say that (a) They are easy to use/to implement? (b) They are easy to understand?	Based on the Likert scale
4	When thinking about these different practices, would you say that: (a) They can be tested without requiring an extensive involvement (capital, labour, training etc…) (b) They can be adapted/modified to suit your own needs	Based on the Likert scale
	(c) They are not necessary to adapt/modify?	Yes/No
5	When thinking about the "observability" of these different practices, would you say that evidence on their potential benefits is available (to ensure a fair judgment of them)?	Based on the Likert scale
6	When thinking again about these different practices, would you say that (a) They are/would be useful in your case? (b) You have already a lot of experiences on similar practices?	Based on the Likert scale

Table 2 Questions asked to farmers on innovation uptake

- Fifth step: To analyse economic impacts of alternative GIN control practices

Similarly to the SDM approach that reflects on consequences of alternatives, in this step we consider economic impacts of various GIN control practices either already applied by some farmers or envisaged for adoption. Social factors are already reflected in the fourth step and further in the next step. Factors of uncertainties and risks are an integral part of the analysis.

The discussion around the economic impacts of different GIN control practices is mainly based on the farm model previously discussed. The farm model considers three main GIN control practices (the same as those of the previous step) but farmers are also given the opportunity to discuss the economic impacts of the other practices they considered to be important at the previous step.

- Sixth step: To consider trade-offs

This step aims at identifying trade-offs between objectives (in relation to evaluation criteria) and eventual implementation of alternative GIN control practices. These trade-offs are determined (1) on the basis of the evaluation criteria specified in the third step, (2) on results and discussion of economic impacts in the fifth step, (3) on results from the short questionnaire addressed in the fourth step, and (4) on barriers to adoption of different GIN control practices.

Result from the short questionnaire (processed in the background) are first presented and discussed. Then, general barriers to adoption are discussed, considering the social, economic, environmental, as well as political and institutional dimensions. On this basis, farmers are then asked to reflect on possible trade-offs between their objectives (& related evaluation criteria) and eventual implementation of alternative GIN control practices.

- Seventh step: To rank alternatives

In this seventh step, the different alternative GIN control practices are ranked by farmers in terms of their preferences (score of importance). A score of importance is calculated in the same way as for the objectives in second step.

- Eighth step: Conclusion and feedback

The purpose of this final step is to conclude the workshop by making a short summary of the results, ask feedback about them and more generally on the workshop, and finally discuss the next steps in terms of research needs and so on.

3. Specific methodology & Results

3.1 Goat system in France (Occitanie and Auvergne-Rhone-Alpes)

3.1.1 Specific methodology

The typical farm used to model impacts of changes in the organic goat system in France comprised the following characteristics:

- Surface of 65 hectares under permanent grassland and grazed forest;
- Herd of 120 dairy goats;
- Production of approximately 55,000 litres of milk per year, (458 litres/goat/annum);
- Use of around 600 grams of concentrated feed per day per goat, comprised of barley, maize, faba bean, and dehydrated alfalfa.

To establish a modelling baseline, we entered the practices that the typical farm applied for parasites control 5 years earlier. These comprised systematic treatment with Fenbendazole (FBZ), 2 to 3 times per year. It must be emphasized that at that time there was a minimal withdrawal period for milk of 2 days. However, since the regulation was changed, the baseline now also takes account of the current rules, with a withdrawal period of 12 days for organic milk (the withdrawal period is only 6 days in conventional).

The GIN control practices now applied by the typical farm were modelled as the alternative GIN control, which the farm model estimated economic impacts:

- The development of Targeted Treatments (TT) and Targeted Selected Treatments (TST) procedures, that includes a gap between primiparous and multiparous producing goats;
- The annual use (on average) of 2 Eprinomectin treatments during lactation, with a withdrawal period of 2 days for organic milk.
- The use of Levamisole during the dry period.
- No access to pasture for goat kids up to one year old.

Furthermore, the typical farm is interested to use Sainfoin to better control parasites but could not test it so far because given the limited availability of dried Sainfoin pellets on the organic market. Although this practice is not applied yet, we considered it in the modelling since it might be an interesting perspective for farmers.

The modelling of the economic impacts of the alternatives mentioned above as compared to the baseline (original situation) comprised six elements: (1) the cost of drenching, (2) the cost of the milk withdrawal periods, (3) the labour cost, (4) the turnover for milk (linked to the production level), (5) the cost of feed (linked to changes in the ration), and finally (6) the gross margin (including direct labour cost). Figure 1 shows the model interface and some of the parameters tested.

Traitement anthelminthique										
		Référence de base			Optimal (évitant l'apparition de résistance)					
	Matière active	Fenbendazole 10%			Eprinomectin 0.5%			Levamisole 3% (tarissement)		
	Dose (mg)	10	mg/kg		1	mg/kg		12	mg/kg	
	Dose (ml)	1	ml/10kg		2	ml/10kg		4	ml/10kg	
	Coût		0,03267	€/ml		0,07268	€/ml		0,01408	€/ml
Moyenne. poids (Kg)			ml/chèvre	€/dose		ml/chèvre	€/dose		ml/chèvre	€/dose
65	Chèvre adulte		6,5	0,21		13	0,94		26	0,37
60	1ère lactation chèvre		6	0,20		12	0,87		24	0,34
80	Bouc		8	0,26		16	1,16		32	0,45
50	Chevreau (8-12mois)		5	0,16		10	0,73		20	0,28
15	Chevreau (3-7mois)		1,5	0,05		3	0,22		6	0,08
		Doses	ml	€	Doses	ml	€	Doses	ml	€
	Chèvre adulte	3	19,5	0,64	1,5	19,5	1,42	1	26	0,37
	1ère lactation chèvre	3	18	0,59	1,5	18	1,31	1	24	0,34
	Bouc	3	24	0,78	1,5	24	1,74	1	32	0,45
	Chevreau (8-12mois)	1	5	0,16	0	0	0,00	0	0	0,00
	Chevreau (3-7mois)	1	1,5	0,05	0	0	0,00	0	0	0,00
Traitement	Coût total Traitements			81,23			178,23			46,02
										224,25
	Retrait du lait (jours)	16		€	2		€	Période tarrissement		€
1	Retrait du lait (adultes)	125	Référence	5991	159	Référence	478			
1	Prod Lait/jour (1ère lac)	18		844	22		67			
Lait retiré	Coût total Lait			6835			545			0
				6917			724			46
	Coûts combinés			6917						770

Figure 1 Illustration of the interface of the farm model

- <u>Cost of drenching</u>

The dose used at each application, per 10kg of animal weight, is respectively of 1, 2 and 4ml for Fenbendazole (baseline), Eprinomectin, and Levamisole (farmacy.co.uk, 2018). The cost of each product as well as the average weight of the goats (distinguishing adult goat, first lactation, billy, dairy KIC and kids) was taken respectively from (farmacy.co.uk, 2018) and Agridea (2017). The model then calculates the cost per dose for each type of goat. Then, the model specifies the number of doses each type of goat is receiving a year (herd average), and an overall annual cost is calculated for each type of goat and for altogether.

- <u>Cost of milk withdrawal periods</u>

The cost of the milk withdrawal period depends on the number of withdrawal days, the milk price and the level of production. The withdrawal period in organic goat system is currently of 16 days for Fenbendazole and 2 days for Eprinomectin (Hoste, 2018). The withdrawal period for Levamisole is 28 days (Hoste, 2018) but is not considered in the model as it is only used in the dry period and generally at the very beginning of it (because the withdrawal period is very long). Since no milk is produced during that period, no financial are be accounted as regard of the withdrawal period. The model then calculates the overall annual cost due to the milk withdrawal periods.

- Labour cost

To account for the cost of labour, the average annual number of hours per worker was defined as 2400 hours and then divided by the number of livestock. The assumed labour cost per hour was 11.26 € in France based on statistical data from Agreste (2018). The model calculates the number of working hours per goat as an indication. To calculate economic impacts of changes in the labour requirement caused by the implementation of more labour intensive practices, the additional labour can be specified as a percentage. In order to present a metric that was easier to assess, the model calculates how many minutes of additional work per day on the farm.

- Milk income

In the model, the milk income directly depends on the production level, which can differ depending on the practices being adopted. The weight of the goats and the effect of parasites are two important elements that are considered.

The weight (and specifically the liveweight gain) of young goats is considered since the fact of keeping kids indoor until they are one year old (a practice assessed) can influence their growth and thus their 1st lactation production level (Alberti et al. 2012). Changes in growth is expressed as a percentage difference and the weight at 1st kidding is adjusted accordingly. Milk yields reflect reality on the modelled farm, with a lower yield assumed for 1st kidders, related to bodyweight. Therefore the model reflects a lower 1st year milk yield with a lower bodyweight at kidding due to parasitism.

For the effect of parasites on milk production, a coefficient of "efficiency" is applied to both adult goats and first year dairy goats. A coefficient of 100% means there is no infection or at least no immediate impact on production from parasites; while a coefficient of 70%, for instance, indicates a decrease of 30% in the production level due to parasites. We assume a coefficient of efficiency of 85% in the baseline (when using Fenbendazole).

- Cost of feed

In the baseline, we assume the use of 600 grams of concentrates per goat annually with a cost of 436€ per ton, based on data from the typical farm. As per the other key variables and the feed used and price changes are expressed in a percentage relative to the baseline.

- Gross margin (including labour cost)

The gross margin is a simple difference between the milk turnover and both variable costs (cost of drenching, cost of feeds) and labour costs.

3.1.2 Farmers' objectives and evaluation criteria

Two focus groups were held in France in Spring 2018; one in Toulouse, Occitanie and one in Valence, Auvergne-Rhone-Alpes. Participants were primarily farmers, together with 1-2 extension staff and 1-2 scientists working in the field of GIN control.

3.1.2.1 Toulouse region

The general objectives expressed by organic dairy goat farmers in the region of Toulouse are (1) maximise the revenue, (2) reduce environmental impacts, (3) enhance the health of the herd, and (4) ensure the resilience of the system and better manage pastures. Table 3 reports the relative importance farmers gave to these objectives, and specifies the evaluation criteria and main comments given. The most important objectives of farmers were economics (maximising the revenue and better resilience), confirming our interest in assessing the economic impacts of the alternative practices. It is also expected that farmers will favourably consider alternatives with direct and clear positive economic impacts.

N°	Objectives	Score of importance	Criteria of evaluation	Comments (actors' statements)
1	Maximising economic results	0.67	Net margin	
			Concentrates expenses	
			Investment and depreciation amount	
2	Better resiliency and pasture management	0.67	Quantity of concentrates, hay and forages bought externally	*"Optimizing the pasture allows buying fewer hay and thus to have a better resilience of the system"* *"To me, the optimization of the pasture involves a similar quantity of milk produced while reducing the quantity of concentrates used"* *"What do we call optimisation of pasture? If it's agronomic, this is the production of herbs […] and on the other side there is practices limiting the infestation"* *"I disagree, this is both in goat system" (production and limited infestation)*
			Quantity of concentrates used per litre of milk produced	
			Decrease in the number of infections per year? (in relation to the quality of pasture)	

				"But I don't know" (about the criteria: decrease in number of infestations)
3	Reducing environmental impacts	0.33	The non-systematic use of products	
			Adoption of practices limiting the resistance	*"To find an equilibrium in all of this"*
			The abandon of "classical" treatments	
4	Ameliorating the herd health	0	Signs of caprine arthritis encephalitis virus (CAEV)	
			Rate of mortality	
			Cull rate due to health issues	
			Overall health status (thinness, etc)	
			Veterinarian expenses	

Table 3 Farmers' objectives and evaluation criteria in Toulouse region

3.1.2.2 Valence region

The general objectives expressed by organic dairy goat farmers in the region of Valence are to (1) ensure viability and decent economic results, (2) have an ergonomic working place and optimised labour workforce, (3) limiting environmental impacts, (4) food autonomy and (5) limiting parasite pressure. Table 4 reports the importance granted by farmers to these objectives and also specifies the evaluation criteria and main comments made. The most important objectives for farmers are of economic nature. Even the second objective, which is more on social aspects at first sight, involve the net revenue as a criteria of measurement. These elements reinforce the interest of assessing the economic impacts of GIN control practices.

N°	Objectives	Score of importance	Criteria of evaluation	Comments (actors' statements)
1	Ensuring viability and decent economic results	0.4	Revenue	*"As I just took over a farm this is very important. […] The balance between production loss and cost of the products, we do not really question it"* (given the low cost of products)
			Pasture management	*"Economically this is ok if I use pastures well"*
			Labour efficiency	*"We have an important constraint on labour so that labour efficiency is important"*
			Mechanisation costs	*"We try to limit mechanisation costs. […] we work with a CUMA"*
2	Ergonomic working place, optimised labour workforce and animal welfare	0.4	Labour quantity	*"These are details maybe but this is an investment in labour making us happier when going to the work"*
			Drudgery of work and workplace adjustment	
			Net revenue	
			How to measure animal welfare?	*"How shall we evaluate the welfare, is it to put animal outside or not?" "Nobody has the answer whether outside is better…" "Ok but when I open the door they go out, they go in forests, etc"*
3	Limiting environmental impacts	0.2	Number of treatments, and dosage applied	
			Molecule toxicity	
4	Food autonomy	0.2	Quantity of concentrates, hay and forages bought externally	

5	Limiting parasite pressure	0	Visual aspect (colour of eyelid, general state, raised hairs or not, etc)	*"It is a risk to take account of raised hairs, when we throw milk away, we throw everything or not […] so I find Targeted Selected Treatments are not that evident"*
			Faecal tests	*"Results are very variable depending on the goat, the lab, etc"* *"We are not sure if the sample sent will arrive the day after or 15 days later"* *"This is also a question of interpretation. Some veterinarians are stricter than others"*
			Cost of treatment	
			Decrease in milk production	

Table 4 Farmers' objectives and evaluation criteria in Valence region

3.1.3 Economic impacts of GIN control practices

- Cost of drenching

The total cost of drenching in the baseline (cost of the products used) was calculated to be 79.10€ for the herd, (using Fenbendazole). There is a non-negligible increase in that cost when using alternative anthelminthic treatments. The use of Eprinomectin and Levamisole for the whole herd costs respectively 170.32€ and 43.98€, thus a total cost of 214.31€. According to the model, the implementation of the alternative drenching practices thus increases the treatment cost by 135.21 euros on an annual basis for the whole herd. But since this cost difference applies on the whole herd, it remains a very small amount at farm level.

Participants in the two workshops agreed on this cost difference between the GIN control practices that were applied 5 years ago and those applied since two years on the typical farm. The participants agreed on the number of doses proposed in the model: 1.5 doses of Eprinomectin and 1 dose of Levamisole for adult, first lactation, and billy goats (alternative practices); as compared to (reference) 3 doses of Fenbendazole for adult, first lactation, and billy goats as well as 1 dose of Fenbendazole for dairy KIC (8-12months) and kids (3-7months).

- Cost of milk withdrawal periods

The withdrawal periods are fixed (regulation), but since the rules often changed in the last few years, there was a question mark as regard of the reference to take into account for the calculation. Indeed, the milk withdrawal period after using Fenbendazole in organic goat systems was of 2 days 5 years ago but is currently at 16 days. It was stressed by the workshops' attendants that the current withdrawal period should be used as a baseline although they also stressed that Fenbendazole should not be used anymore because of resistance problems.

If Fenbendazole was currently used for goat systems in France, this would imply an annual cost of 8,215€ due to the milk being withdrawn. The current use of Eprinomectin has an annual milk withdrawal cost of 521€. Thus, the annual cost associated to milk withdraw decreases by 7,694€ when implementing the recent GIN control practices selected. Workshops' participants had no specific comments or concerns on this result.

- Labour cost

It was hypothesised that implementing the recent GIN control practices implies additional work, mainly due to the need to observe goats in a more individual way. In the baseline, it was assumed that two full-time employees, working each 2'400 hours a year on the farm, represents an annual cost of 54'572 €.

When implementing the new GIN control practices, it was hypothesized that an increase of 5% in the number of hours required being tested. This represents extra work of 39 minutes per day and an additional annual cost of **2'734** € (total cost of 57'406 €). The participants stressed that 39 minutes of extra work per day is probably an overestimation.

It was highlighted that there is probably a need to work 5% more but that the reference of 2’400 hours a year per worker is probably too high. We reduced the reference to 1’800 hours, reducing the extra daily work to 30 minutes. This result was fine for the attendants. With this new hypothesis, the labour cost for the baseline decreases to 41’265 €. The labour cost for the recent GIN control practices also decreased to 43’328 €. With this new hypothesis, the labour cost difference decreases to 2’063 € (as compared to 2’734 €).

Moreover, it must be emphasized one farmer managing a particular system (not the one tested in the modelling) estimated an additional work of half a day per month as compared to his old system. In fact, this farmer uses electric fences in pastures to operate rotational grazing, implying significant work for the installation and shifting of fences.

- Milk income

Two elements were discussed with respect to the milk turnover: possible changes in the growth of goats (and thus in their end weight) and in the effect of parasites (the “efficiency”), potentially impacting the level of production and thus the milk turnover.

For the workshop, it was hypothesised that there would be no change in the growth nor in the “efficiency”. When participants were asked whether keeping kids indoor favours their growth, they answered that there was no clear evidence. One farmer even said that keeping kids indoor is worse because the first time they go outside their immune system is less well developed and they are thus more affected by parasites. This also answers the second question about changes in the efficiency: there are also no clear evidence on this and the level of production might even decrease in certain places. Participants stressed that there are many factors influencing the level of production and that it is therefore difficult to isolate one factor or another. None of the farmers clearly observed an increase in the production level. However, one farmer mentioned that on average (when using Fenbendazole), 5 to 6 goats were removed annually with the past system while only one is removed per year currently. That said, the other farmers did not notice any significant difference.

Therefore, according to stakeholders, the milk turnover is not affected by the adoption of the recent GIN control practices being tested here, and no changes in the model are required.

- Cost of feed

In the model, we hypothesised no change in the quantity of concentrates used. For the possible adoption of Sainfoin, we hypothesised an increase of 5% in the cost of concentrates, though this is estimated due to a lack of reliable information. Sainfoin is indeed more expensive given its limited availability on the organic market. The possible use of Sainfoin was not reflected on in-depth at the workshops but farmers believe there is no clear economic impact on the production system. We kept the hypothesis formulated as there was no clear disagreement from farmers.

- <u>Gross margin</u>

With the implementation of the recent GIN control practices being tested (and assuming a withdrawal period of 16 days for Fenbendazole), the annual gross margin on the typical farm increases by around 4'918 € (41 €/goat). This is mainly due to savings from fewer quantity of milk withdrawn. There is also a slight increase in the cost of feed due to the use of Sainfoin but the latter could not be reflected in-depth in workshops.

3.1.4 Economic impacts of other new GIN control practices (not modelled)

3.1.4.1 Toulouse region

The stakeholders highlighted two other GIN control practices they consider important as alternatives to anthelminthic treatments: (1) the genetic selection for parasites resistance as well as (2) reseeding of pastures at times in order to limit infestation. The alternative practice "changes in the pasture system", addressed in the questionnaire but not modelled, was not considered here as it is a very general practice (economic impacts might vary considerably depending on the specifics).

It was said it is difficult to assess the impacts of these two practices without knowing much on the situation of reference. That said, one farmer stated that genetic selection for parasites resistance is not necessarily more expensive: "why would it be more expensive as instead of selecting on the protein content [of the milk], we select on parasites [resistance]". Another farmer said that "reseeding pastures is obviously more time consuming" (tillage, etc).

3.1.4.2 Valence region

The stakeholders highlighted 5 other GIN control practices they consider important as alternatives to anthelminthic treatments: (1) the genetic selection for parasite resistance (2) the elimination of infected goats, (3) limiting the width of the passages to 2.50 meters to avoid goats staying long and building a parasite reserve, (4) using essential oil (e.g. strong dosage of garlic) and (5) using fresh oak leaf.

It was said that it is difficult to assess the impacts of these practices. Farmers highlighted that these GIN control practices are more preventive than curative so that it is very difficult to assess the difference. Also no faecal egg measurement was undertaken before and after, however farmers envisage such testing could be done and they call for systematic experiments. However, the high cost of such experiments was mentioned, as they need to be meticulously implemented and control groups must be used.

Most of these alternatives limit the level or risk of infestation but are not intended to eradicate or significantly decrease parasite strains. This particularly applies for the use of essential oils and oak leaf. One farmer said *"one year we had a lot of hassles with parasites.*

We tried essential oils that stabilized parasitism but this is not curative. Where essential oils was not used, the parasitism level continued to increase and I had to undertake chemical treatments".

3.1.5 Drivers and barriers to innovation uptake

3.1.5.1 Drivers

Highlights from the questionnaires completed by farmers at the two workshops are shown below. There were no major differences between the two workshops, so the data was merged. In a second section, detailed results are shown.

- <u>Highlights: Questionnaire results</u>
    - No access to pasture for kids is not more efficient than current (or previous) practices according to 3/5 of the farmers. For the other strategies, from 6 to 7 out of 7 farmers agree or strongly agree that they are more efficient than their current (or old) practices.
    - 5/5 farmers said the practice "non-access to pasture for kids" is not in line with their beliefs and values. This practice is also not easy to understand for 4/7 of the farmers (compared to 0 to 1 out of 9 farmers for the other practices); still, only 1/5 of the farmers agree that this strategy can easily be adapted to suit their system (compared to 6 to 8 out of 6 to 8 farmers for the other strategies).
    - The adoption of the practice "non-access to pasture for kids" is not influenced by the surrounding social context according to 4/6 of the farmers. By contrast, from 5 to 6 farmers out of 6 to 7 agree or strongly agree that TST and the strategic use of anthelmintic are influenced by the surrounding context (these two practices are actually adopted the most).
    - 6 to 7 out of 7 to 8 farmers agree or strongly agree that TST and strategic use of anthelmintic are easy to use. This is only 3/7 for "non-access to pasture for kids", 3/8 for changes in pasture system (with 4 farmers disagreeing), and 3/7 for the use of bioactive plants (with 2 farmers disagreeing).
    - 6/8 of the farmers disagree or strongly disagree that changing the pasture system is a strategy that can be easily tested without requiring an extensive involvement (labour, resources…).
    - 5/6 to 6/6 of the farmers affirm to have already many experiences on similar practices as TST and the strategic use of anthelmintic, which might partly explain the higher adoption for these two practices.

- <u>Detailed results from the questionnaire</u>

Figure 2 to Figure 11 shows the results from the questionnaire completed by farmers in the workshops.

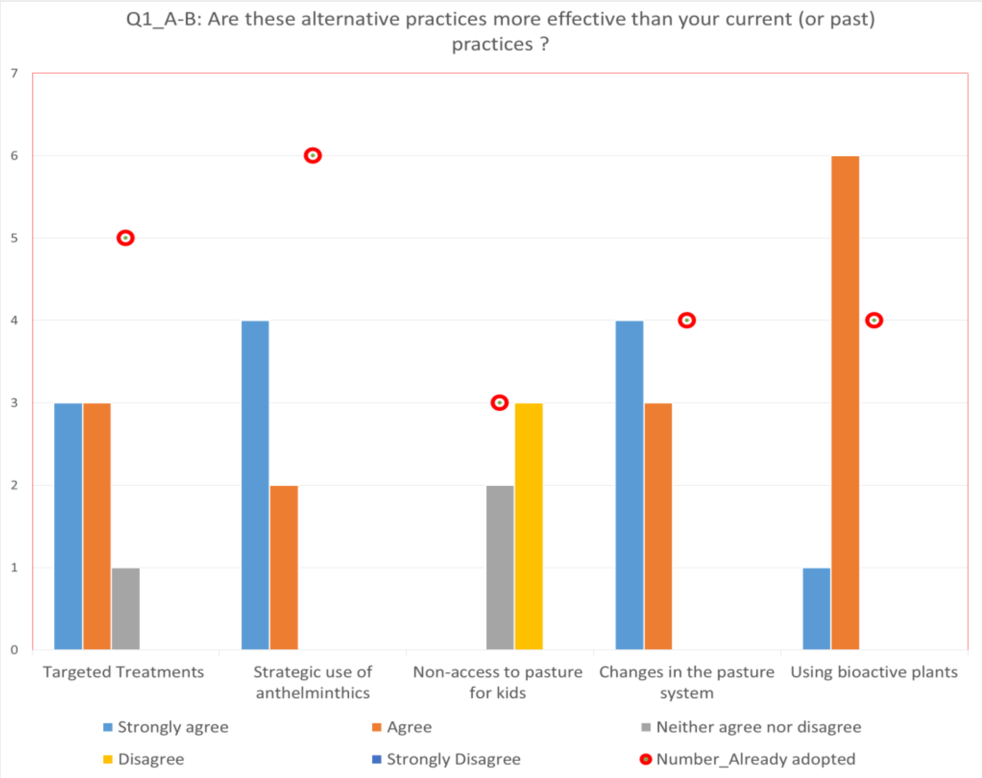

Figure 2 Effectiveness of alternative GIN control practices

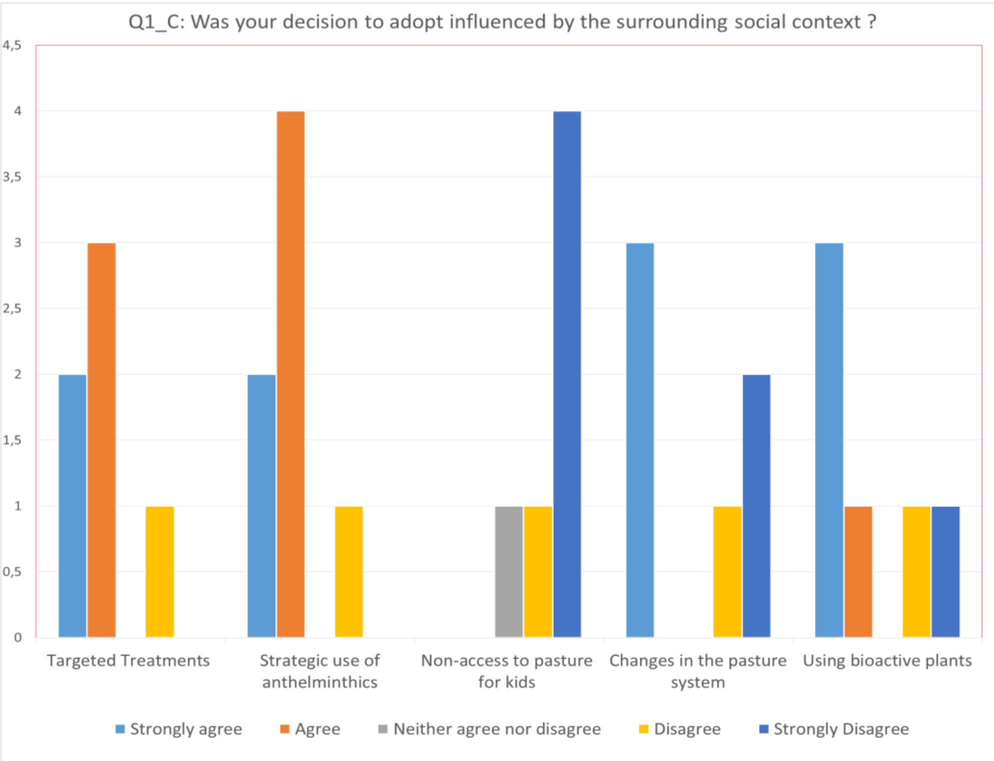

Figure 3 Social context and alternative GIN control practices

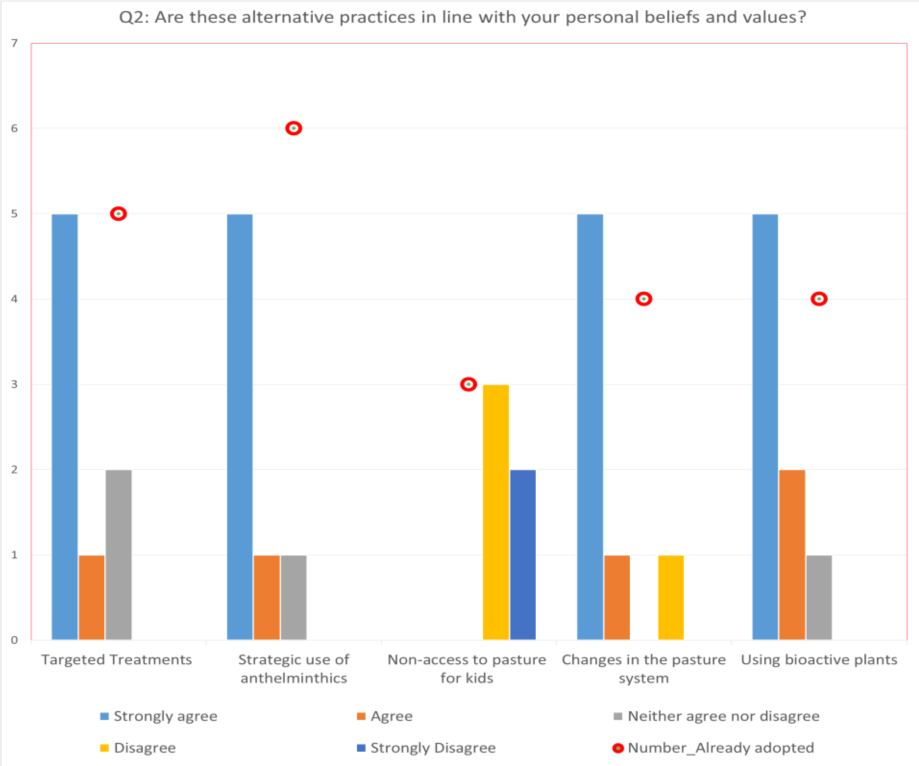

Figure 4 Personal beliefs & values and alternative GIN control practices

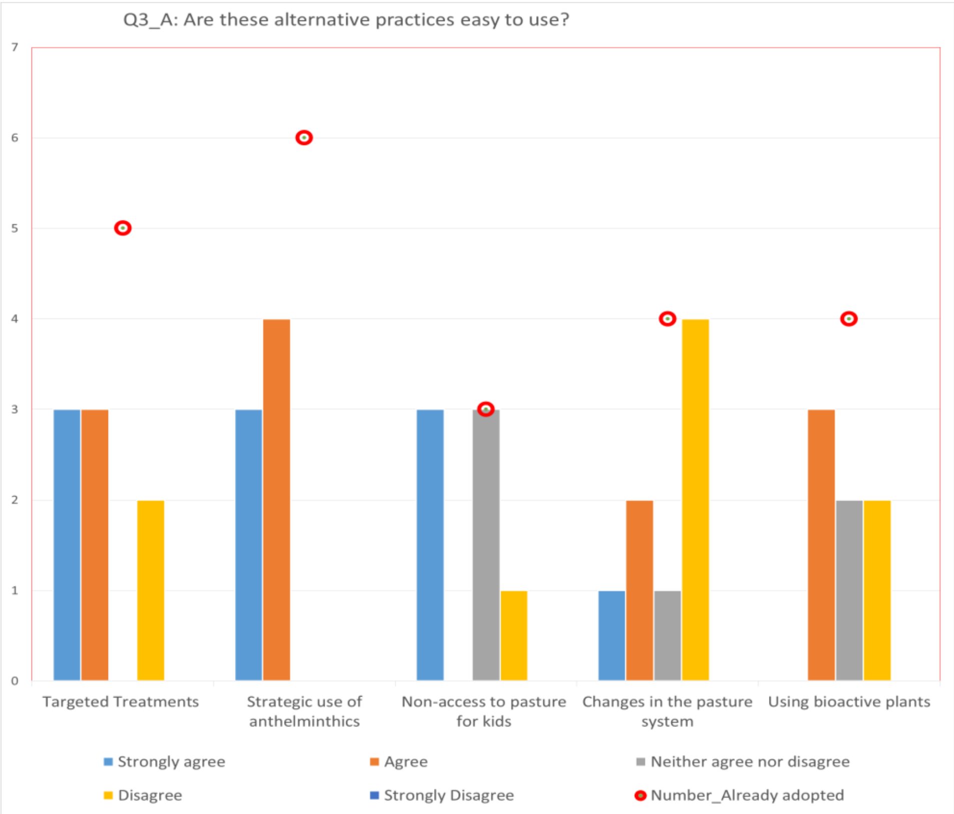

Figure 5 Practical use of alternative GIN control practices

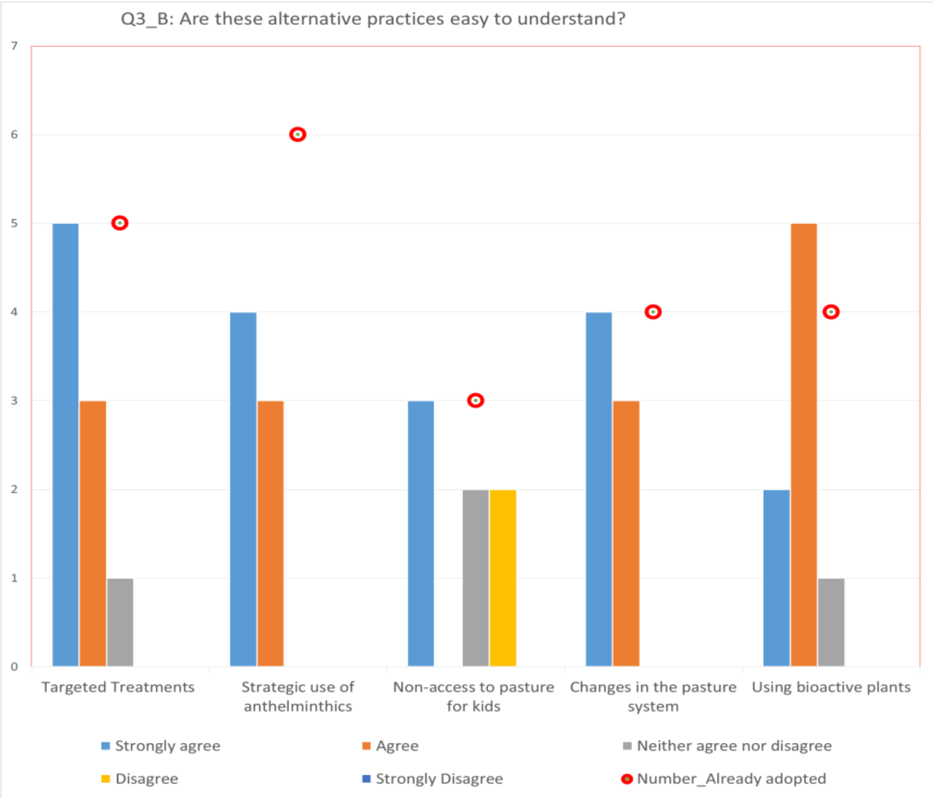

Figure 6 Understanding of alternative GIN control practices

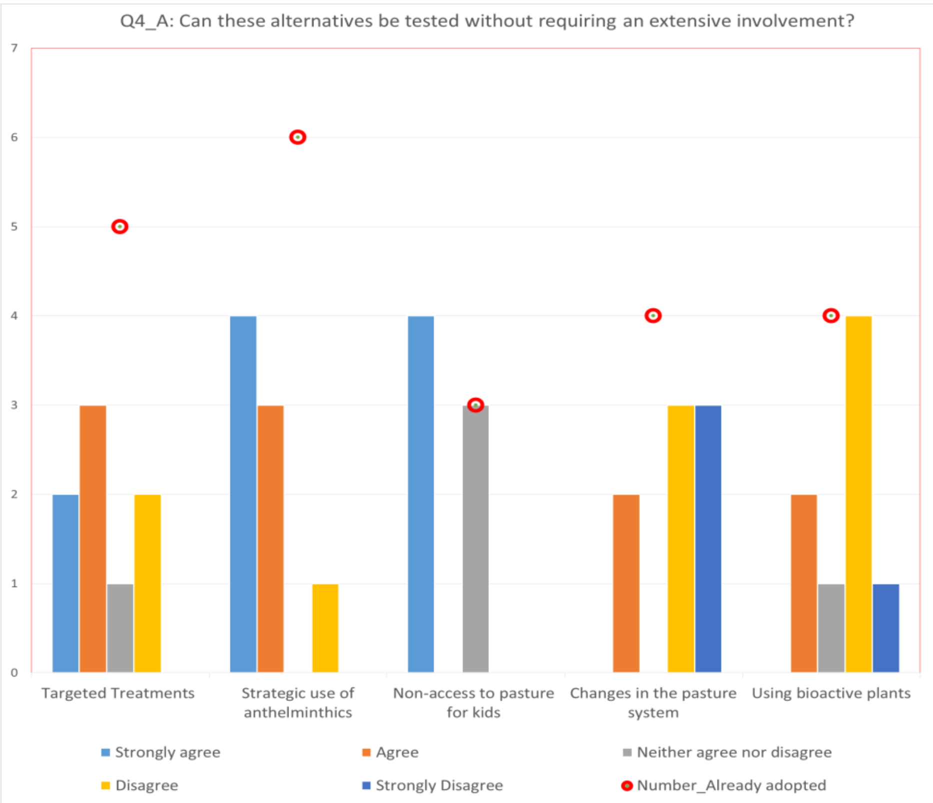

Figure 7 Alternative GIN control practices and required involvement

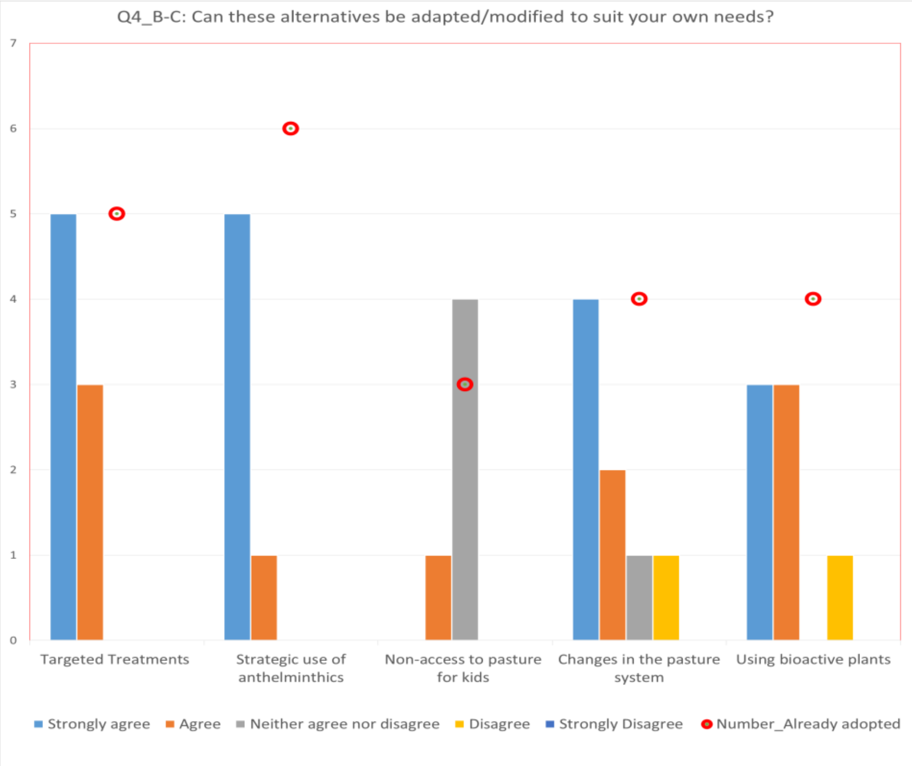

Figure 8 Adaptability of alternative GIN control practices

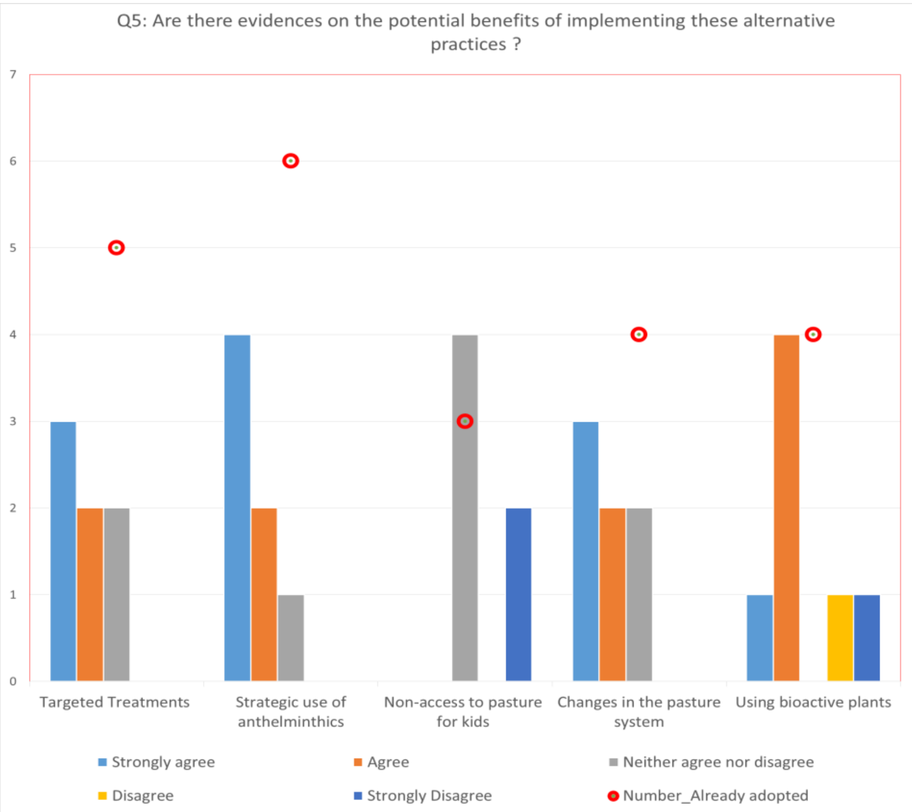

Figure 9 Evidences on benefits of alternative GIN control practices

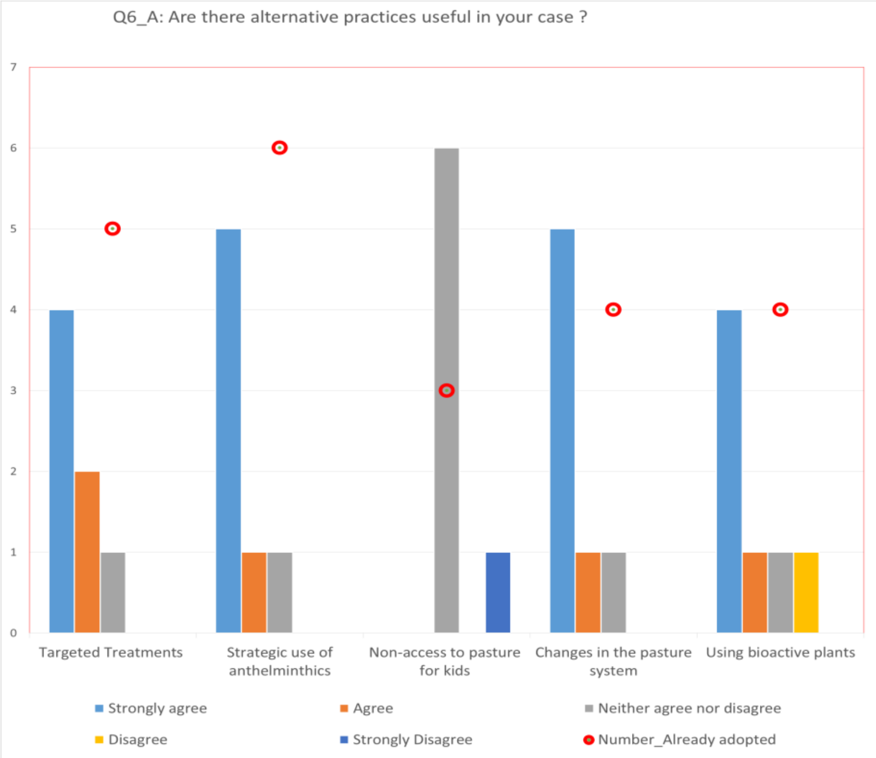

Figure 10 Usefulness of alternative GIN control practices

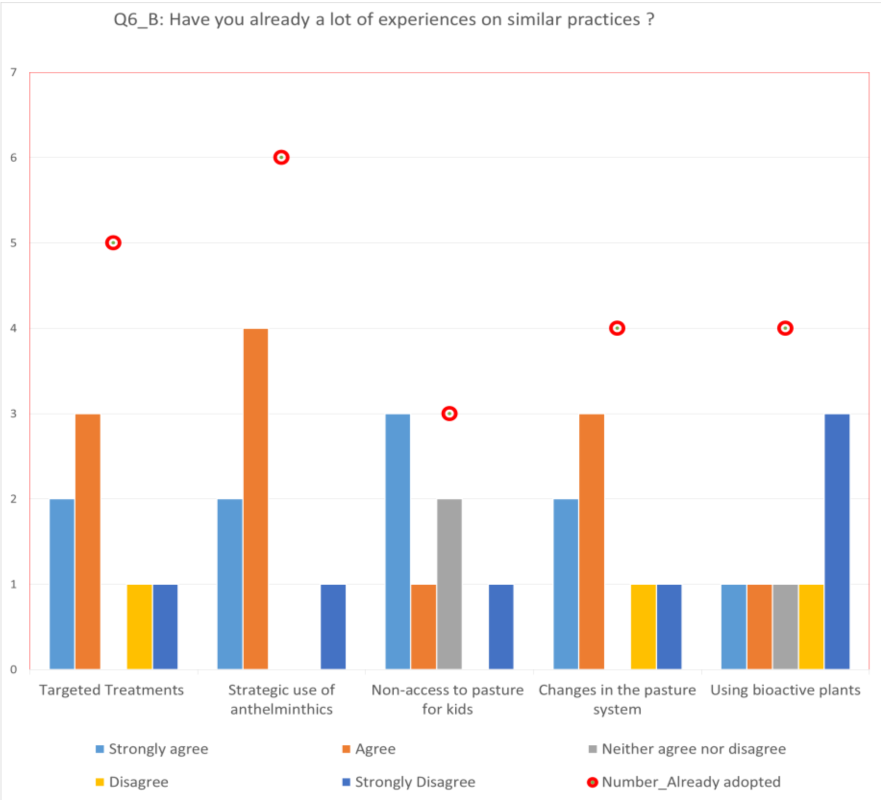

Figure 11 Experiences on similar practices

3.1.5.2 Barriers

General economic and social barriers to innovation uptake were expressed by farmers in the workshops. These are as follows:

- Economic:
  - *"The economic results maybe, if we take account of the number of working hours"* (one farmer)
  - *"Partly, this is starting from unknown, we take a risk that is not measurable"* (one farmer)
  - *"I did not adopt the strategy of Targeted Selected Treatment as I just have taken over a farm and the economic risk is too high […]; systematic treatments are less risky"* (one farmer)
- Social:
  - *"The additional time" (one farmer)*
  - *"Farmers are more and more trained while technicians have less time to do so, therefore we do not make substantial progress; there is insufficient information on research, on what is going on"* (one farmer); another farmer expressed a similar view
  - *"The interpretation of lab results on faecal samples (number of eggs) is sometimes very different between veterinarians and we do not know where to stand"* (one farmer). *"There is a problem to conserve faecal samples; we tested small bags of silica to absorb oxygen in the samples", which works quite well"* (an adviser)
  - *"If when we go to the veterinarian, he/she does not know what a goat is, this is annoying"* (one farmer)

3.1.6 Importance of recent GIN control practices

Table 5 and Table 6 indicate the score of importance of the different GIN control practices considered in Toulouse and Valence regions respectively, based on the ranking made by farmers. We can see that changing the pasture system was considered as the most important GIN control practice as alternative to anthelminthic treatment. The practice "genetic selection" obtained an importance score of 0.33 in Toulouse but was not acknowledged in Valence.

It is interesting to see a certain coherence between farmers' objectives (and related evaluation criteria) and their ranking of the alternative practices. The most important objectives of farmers are economic in nature and all GIN control practices without clear economic benefit were not considered well here (e.g. non-access to pasture for kids).

This ranking can also be partly explained by the different barriers and social factors to innovation uptake for the different alternative practices. GIN control practices that were not acknowledged well in the questionnaire are also not well considered here. This is particularly the case for the practice "non-access to pasture for kids", which faced quite some limitations: (1) problem of efficiency; (2) not in line with farmers' values and beliefs; (3) not easy to understand; (4) low level of adaptability; (5) low influence of the social context for adoption; and (6) not easy to implement. Furthermore, the strategy of changing pasture system was considered by farmers as not easy to test without an extensive involvement. But this practice was ranked first (largely), meaning that labour requirement is not directly a very important issue for most farmers (it is an issue when additional people have to be hired). The ranking was mainly driven by future perspectives in terms of economic gains. The level of risk involved is also an issue as it was raised to be a barrier for 2 farmers out of 9.

N°	Alternatives	Score of importance	Comments
1	Changes in the pasture system	0.67	Seen as a potential for the future
2	Genetic selection for parasites control	0.33	
3	Targeted treatments (TT) and targeted selected treatments (TST)	0	Considered as the current "standard", however two farmers ranked it in second place
4	Strategic use of anthelminthic treatments	0	
5	Non-access to pasture for kids	0	Unclear impacts
6	Using bioactive plants (including Sainfoin)	0	No scientific evidences yet

Table 5 Importance of GIN control practices in the Toulouse region

N°	Alternatives	Score of importance	Comments
1	Changes in the pasture system	4	
2	Using bioactive plants (including Sainfoin and oak leaf)	0	Two farmers ranked it in second place
3	Elimination of infected goats	0	Two farmers ranked it in third place
4	Genetic selection for parasites control	0	
5	Targeted Treatments (TT) and Targeted Selected Treatments (TST)	0	
6	Strategic use of anthelminthic treatments	0	
7	Non-access to pasture for kids	0	
8	Using essential oils	0	
9	"Waiting area" of 2.50 meters	0	

Table 6 Importance of GIN control practices in the Valence region

3.2 Sheep system in Scotland

3.2.1 Specific methodology

In Scotland, two typical farms were used to model impacts of changes in both upland and lowland beef & sheep farm. They present the following characteristics:

- Upland beef & sheep system
- 50 ha of cereals
- 150 ha of rotational forage (grass & roots)
- 890 ha of hill grazing for sheep
- 900 ewes and finishing lambs (100% lambing)
- 140 suckler cows and finishing beef

- Lowland beef & sheep system
- 50 ha of cereals
- 150 ha of rotational forage (grass & roots)
- 100 ha of hill grazing for sheep (and 100 ha of environmental areas)
- 400 ewes and finishing lambs (175% lambing)
- 70 suckler cows and finishing beef

To establish the baseline of the modelling, for each of these systems, we considered the practices the typical farms applied for parasite control 5 years earlier. These were an annual application of 2 doses with white (benzimidazole) drench per ewe as well as 2 to 3 treatments for lambs.

The GIN strategies that are currently or could be applied in the near feature in these two different systems (and of which the farm model estimates their economic impacts) are:

- Reduction of the stocking rate
- Drenching part of the flock e.g. on the most susceptible animals
- Targeted selected treatment (TST) e.g. individual monitoring and drenching
- Increase protein level fed (particularly for ewes at lambing)
- Use of bioactive feeds like Sainfoin or Chicory

The modelling of the economic impacts of the alternatives mentioned above was compared to the baseline (original situation) comprising six elements: (1) the cost of drenching, (2) the labour cost, (3) the production effect, (4) the cost of feed (linked to changes in the ration), and finally (5) the gross margin (including the labour cost). Figure 12 is an illustration of how the interface of the model, where changes in parameters can be tested, looks like.

Anthelmintic Treatments										
		Baseline					Optimal			
	Chemical name	Panacur 10%					Panacur 10%			
	Dosage for sheep	5	mg/kg				5	mg/kg		
	Product dose	0,55	ml/10kg				0,55	ml/10kg		
	Cost		0,032936	£/ml				0,032936	£/ml	
Avg. bodweight (Kg)			ml/sheep	£/dose				ml/sheep	£/dose	
70	Breeding ewe		3,85	0,13				3,85	0,13	
80	Rams		4,4	0,14				4,4	0,14	
50	Ewe lambs		2,75	0,09				2,75	0,09	
35	Lambs 7mths		1,925	0,06				1,925		
30	Lambs 5mths		1,65	0,05				1,65		
25	Lambs 3mths		1,375	0,05				1,375	0,05	
		Doses	ml	£			Doses	ml	£	
Breeding ewe	918	2	7,7	0,25		918	1	3,85	0,13	
Rams	26	2	8,8	0,29		26	1	4,4	0,14	
Ewe lambs	206	1	2,75	0,09		206	0	0	0,00	
Lambs 7-8mths	877	1	1,925	0,06		877	0,5	0,9625	0,00	
Lambs 5-6mths	916	1	1,65	0,05		916	1	1,65	0,00	
Lambs 0-4mths	964	1	1,375	0,05		964	0	0	0,00	
Anthelmintic tr	Total cost of treatments			408					120	
Ewe productivity effects										
		Baseline					Optimal (efficiency through targeted GIN control)			
	Ewes/ha	2,5	0,369846	Sheep LU/ha			2,5	100%	0,369846	Sheep LU/ha
	Lambing %	105%		964	Lambs		105%	100%	964	Lambs
	Lambs 0-4mths	3,5					3,5			
	Weaning weight	22,0	0,15	DLWG			22,0	0,15	DLWG	
	Lambs weaned %	95%		916	Lambs		95,00%	100%	916	Lambs

Figure 12 Screenshot of the interface of the farm model

- <u>Cost of drenching</u>

The dose used at each application, per kg of animal weight, is respectively of 5mg (farmacy.co.uk, 2018). The cost of each product as well as the average weight of the sheep (distinguishing breeding ewe; rams; ewe lambs; lambs of 3, 5 and 7 months) was taken from farmacy.co.uk (2018) and SAC Consulting (2017), respectively. The model then calculates the cost per dose for each type of sheep and the number of doses each type of sheep receives on average per year, and subsequently the overall annual cost per class of sheep and in total.

- <u>Production effect</u>

The production effect is mainly focused on the ewes. The model computes the number of ewes per hectare on average with the lambing percentage, thus providing the number of lambs from 0 to 4 months. We assumed identical values for both lowland and upland system. The model effectively tries to identify, if we dose less, whether the numbers of lambs born and then weaned is likely to be very different. If we dose less, it is likely that the ewes produce less milk because of more parasites. There would be, in turn, increased mortality in the lambs and a lower growth rate. This would then impact the income from lambs. The model assumes no difference between the baseline (old system with more treatments) and the new system. Stakeholders were asked in workshop to specify their views on this.

- Labour cost

Labour costs per hour were assumed on the same basis as the goat farms, except for a wage rate of 10.26 € in Scotland based on SAC Consulting (2017).

- Cost of feed

In the baseline, neither farm fed concentrates to their sheep.

- Gross margin (including labour cost)

The gross margin is a simple difference between the turnover and both variable costs (cost of drenching, cost of feeds) and labour costs.

3.2.2 Farmers' objectives and evaluation criteria

A single focus group was held in Scotland, UK in spring 2018 at the SRUC Aberdeen campus. Participants were primarily farmers, together with 1-2 extension staff and 1-2 scientists working in the field of GIN control.

The general objectives expressed by organic sheep farmers in Scotland are; (1) to increase the farm economic viability, (2) have a resilient system, (3) to optimise the workload and (4) have an environmentally balanced system. Table 7 reports the importance given by farmers to these objectives and also specifies the evaluation criteria and main comments provided. The most important objectives of farmers are the economic viability and system resilience, reinforcing the interest of assessing the economic impacts of the different GIN control practices. We also expect that farmers will better consider alternatives with direct and clear positive economic impacts.

N°	Objectives	Score of importance	Criteria of evaluation	Comments
1	Economic viability	0.4	Revenue / Profit	
2	Resilient system	0.4	Long term productivity / Adaptability; Diversified / Mixed enterprises; Lower risks; Preventative healthcare	*"I want as much preventative measures as possible"…. I do not enjoy drenching so I have been doing some selective drenching"* *"To diversify as well, as I'm struggling having enough clean pastures"*
3	Optimising workload	0.2	Number of working hours	

4	Environmentally balanced system	0	Minimising the use of inputs; adaptation to climate change	*"I am advisor…My primary objective is to have enough time"* *"Earning enough to live but not maximising revenue"*

Table 7 Farmers' objectives and evaluation criteria in Scotland

3.2.3 Economic impacts of alternatives modelled

- Cost of drenching

In the lowland system, the total cost of drenching (cost of the products used) calculated with the farm model was 221£ (per flock) for the reference (use of fenbendazole) and 210£ for the tested practice (use of Cydectin). For the upland system, the total drenching cost for the reference and the tested practice was 408£ and 120£, respectively.

Participants in the workshop had no specific comments on this but mentioned that the additional cost is actually more with the labour.

- Production effect

In terms of the stocking rate, the Scottish farmers said that reducing the stocking rate is maybe not the right thing to do for lowering the number of doses applied. It was reported that keeping the grass at the right stage for grazing is the most important and that it's better to achieve an optimal stocking rate (rather than reducing it) that allows keeping a good grass quality for the year.

One farmer highlighted that if we assume the system is optimised for using clean grazing, it should be possible to achieve the same production level by treating lambs once instead of twice. Another farmer said he has pretty clean grazing and that he only applies one dose on average. However, one farmer said he is struggling to keep the grass clean and that is trying chicory with some sheep to see the effect.

But the farmers had difficulties to estimate the effect of reducing the dosage for lambs given the high complexity of the system and the need to understand all the components of it. The control of another pasture parasite, liver fluke can also influence GIN control strategies as some products will treat both issues. We thus still assume no effect on the production level.

- Labour cost

It was hypothesised that implementing the alternative GIN control practices tested does not imply additional work requirements on farm, either for lowland or upland systems. In the baseline, it was assumed 2 full-time employees, working each 2'400 hours a year on the farm, representing an annual cost of 43,200£. The workshop attendants highlighted that the more targeted approach to treatments do require more skills and time, although they encountered difficulties in estimating the difference with a conventional system. Furthermore, one farmer reported to have invested in an automatic identification (ID) system that allows sheep to be sorted based on growth rate. This required a large investment (5 years investments) but saves on labour costs.

- Cost of feed

No change was assumed in the model.

- Gross margin

With the implementation of the alternative GIN control practices tested, the annual sheep enterprise gross margin on the typical farm is stable in lowland systems (negligible increase of 12£ annually for the entire flock) and slightly increasing by 288£ in upland systems. These slight differences are entirely due to changes in the cost of drenching, itself due to a decrease in the doses applied. However, farmers highlighted that it is quite hard to estimate as farms are very complex systems and diverse.

3.2.4 Drivers and barriers to innovation uptake

3.2.4.1 Drivers

Below are the highlights from the questionnaire completed by farmers in the workshop. In a second section, detailed results are shown.

- Highlights: questionnaire results
    - 4/5 of the farmers agree or strongly agree that the practice consisting of drenching part of the flock is more effective than current (or past) practices. For the other practices, only 2 to 3 farmers out of 5 agree or strongly agree that they are more effective than their current (or old) practices.
    - The adoption of the practice "increased protein" was influenced by the surrounding social context according to half of the farmers (agree or strongly agree). By contrast, only 1 farmers out of 5 strongly agree or agree that the adoption of the practice "drenching part of the flock" was influenced by the surrounding social context. And for the other practices, none of the farmers said that their adoption was influenced by the surrounding social context.
    - All farmers (5/5) agree or strongly agree that the practices "increased protein" and "bioactive feeds" are in line with their personal beliefs and values. By contrast, 3/5 of the farmers agree or strongly agree that reducing the stocking rate and drenching part of the flock are practices that are in line with their personal beliefs and values.
    - 4 farmers out of 5 agree or strongly agree that the practices "drenching part of the flock" and "increased protein" are easy to implement. And 3 farmers out of 4 agree that reducing the stocking rate is easy to apply. For the other practices, only 2 to 3 farmers out of 5 agree or strongly agree that they are easy to implement.

- All farmers agree or strongly agree (5/5) that the practices “drenching part of the flock”, “TST” and “drenching part of the flock” can be tested without an extensive involvement (resources, labour, etc). In more details, these include 2 farmers of 5 that strongly agree on this for the practice “drenching part of the flock” (compared to 0 for TST). By contrast, only 3/5 and 1/5 of the farmers agree or strongly agree that the practices “increased protein” and “bioactive feeds” can be tested without an extensive involvement.
- All farmers (5/5) agree or strongly agree that that there are scientific evidences on the potential benefits of adopting the practice “reducing stocking rate”. By contrast, 4/5 of the farmers agree or strongly agree on this for the practices “drenching part of the flock” and “increased protein”; and only 3/5 of the farmers concerning TST and the use of bioactive feeds.
- Only 1/5 and 1/4 of the farmers agree or strongly agree that they already have a lot of experiences on similar practices as TST and the use of bioactive feeds, respectively. By contrast, 2/5 and 3/5 of the farmers agree or strongly on this for the practices “reducing stocking rate” on the one hand and “drenching part of the flock” and “increased protein” on the other.

- <u>Detailed results from the questionnaire</u>

Figure 13 to Figure 22 show all results from the questionnaire that was filled by farmers in the workshops.

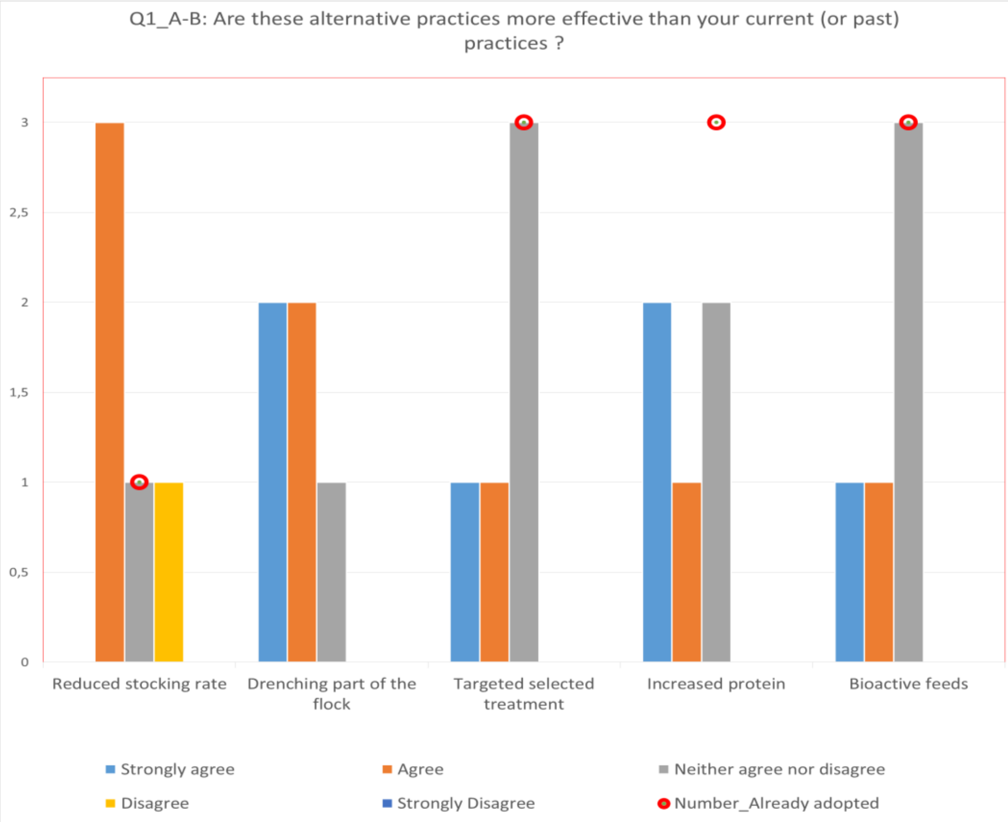

Figure 13 Effectiveness of alternative GIN control practices

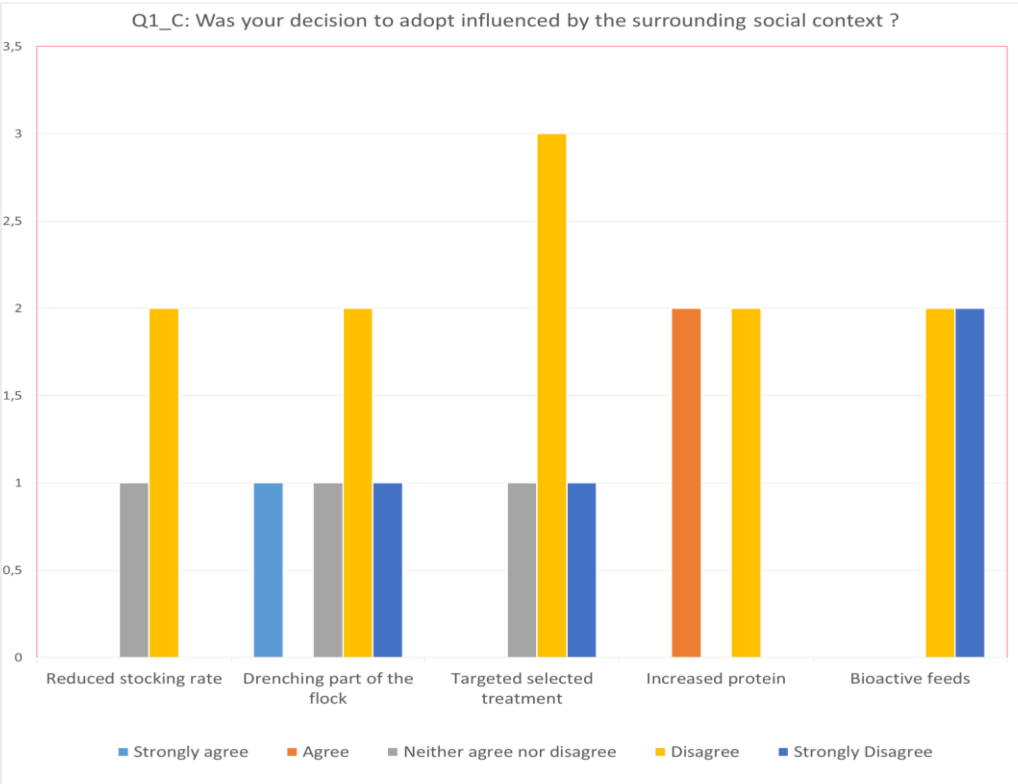

Figure 14 Social context and alternative GIN control practices

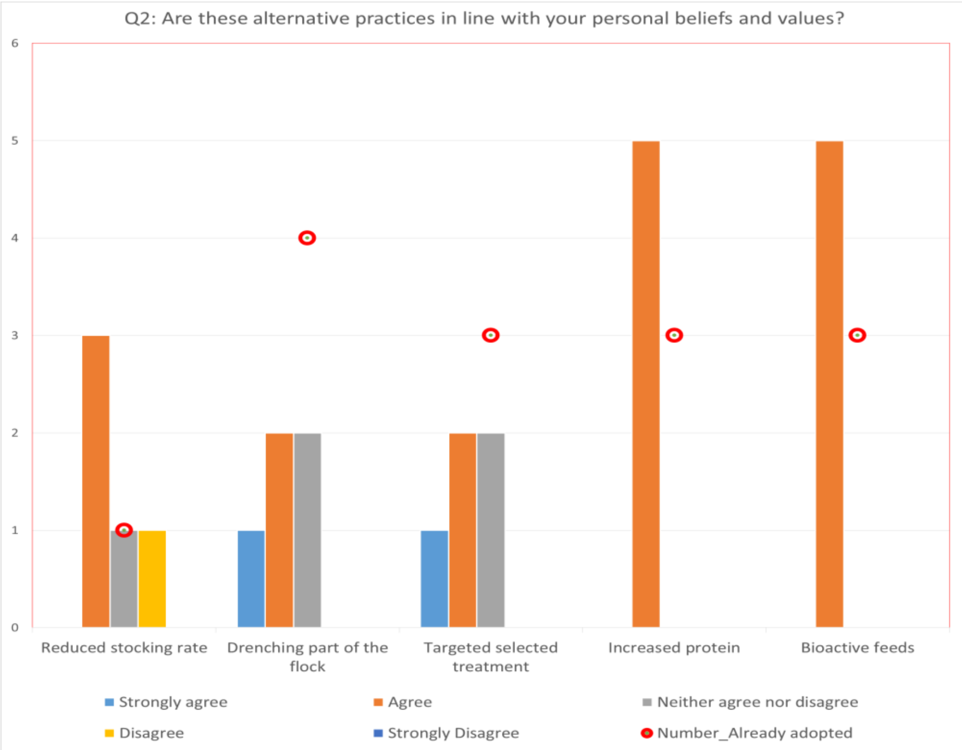

Figure 15 Personal beliefs & values and alternative GIN control practices

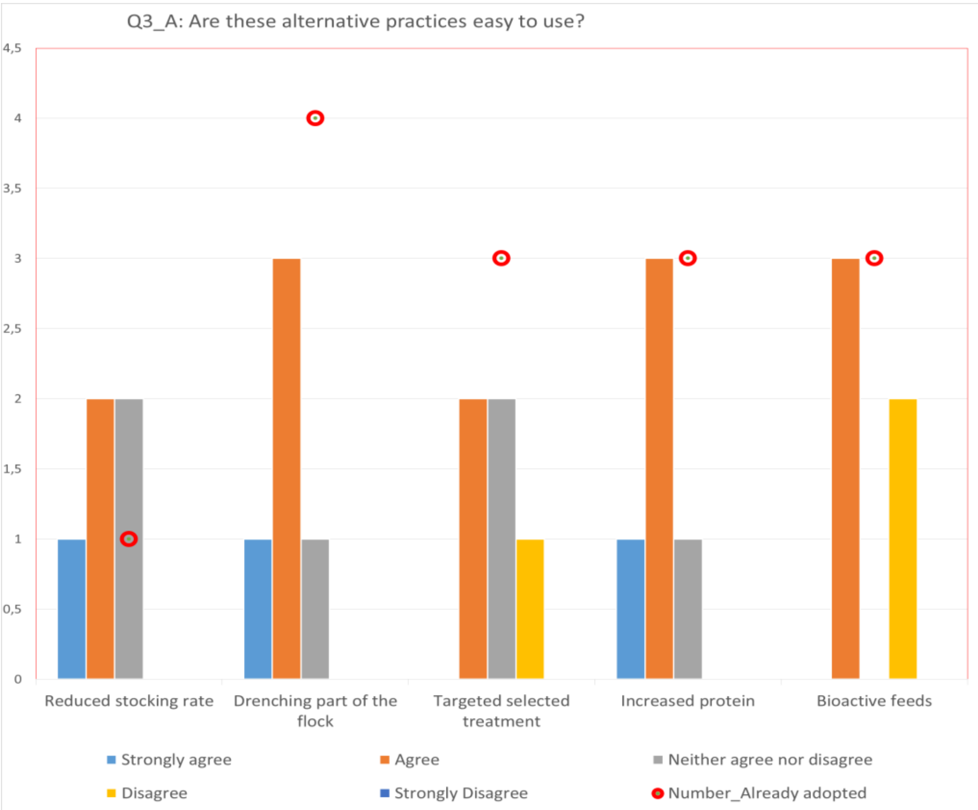

Figure 16 Practical use of alternative GIN control practices

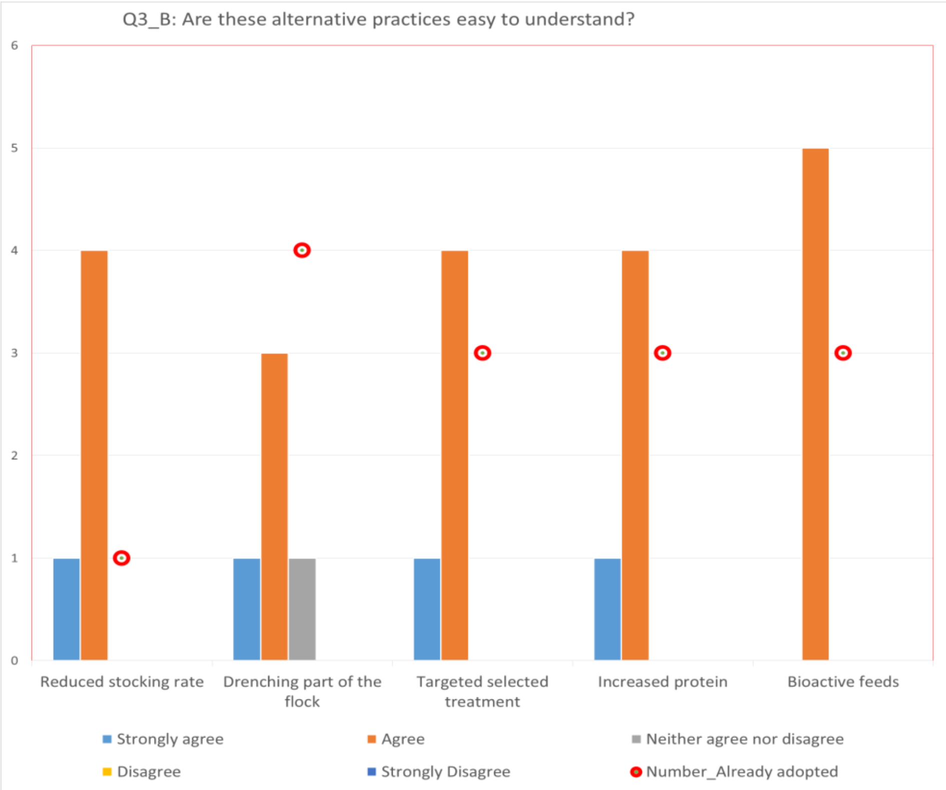

Figure 17 Understanding of alternative GIN control practices

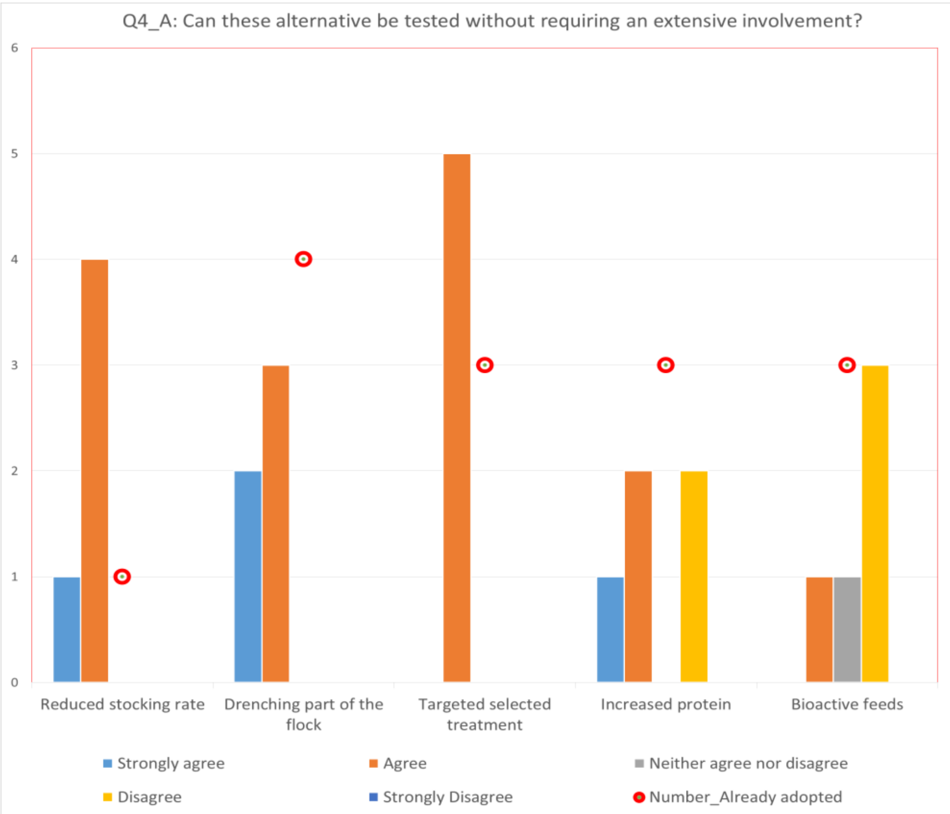

Figure 18 Alternative GIN control practices and required involvement

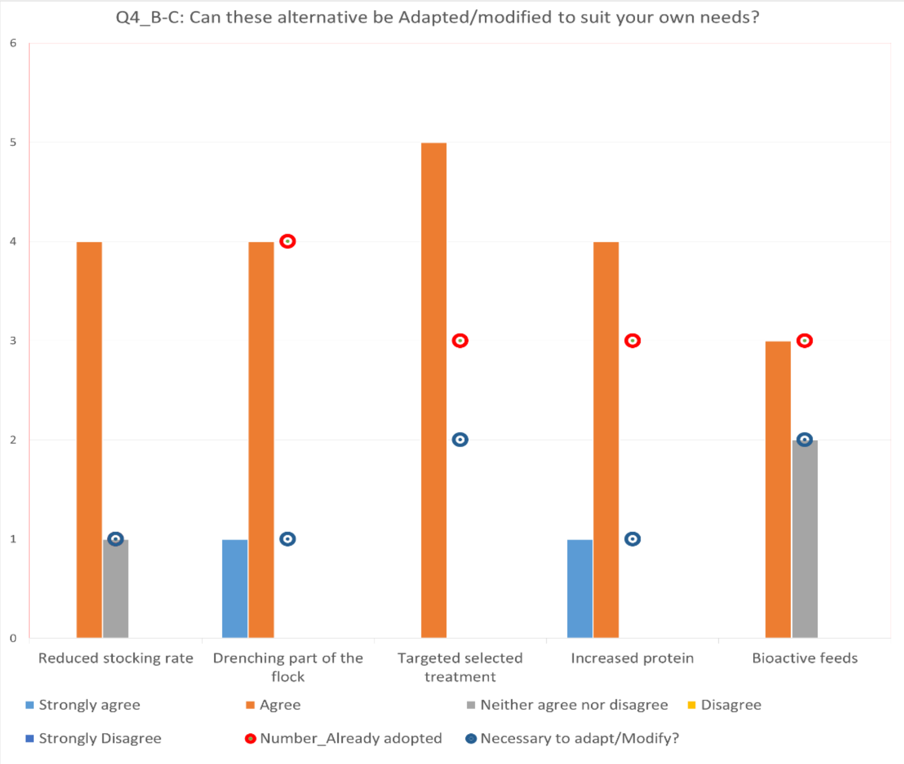

Figure 19 Adaptability of alternative GIN control practices

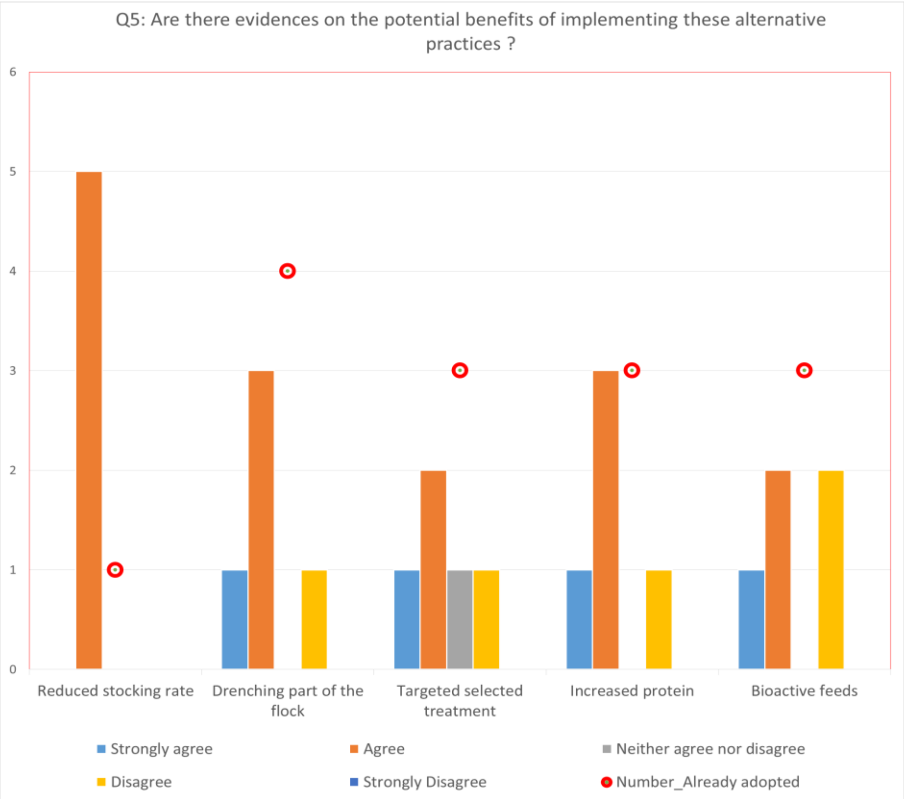

Figure 20 Evidences on benefits of alternative GIN control practices

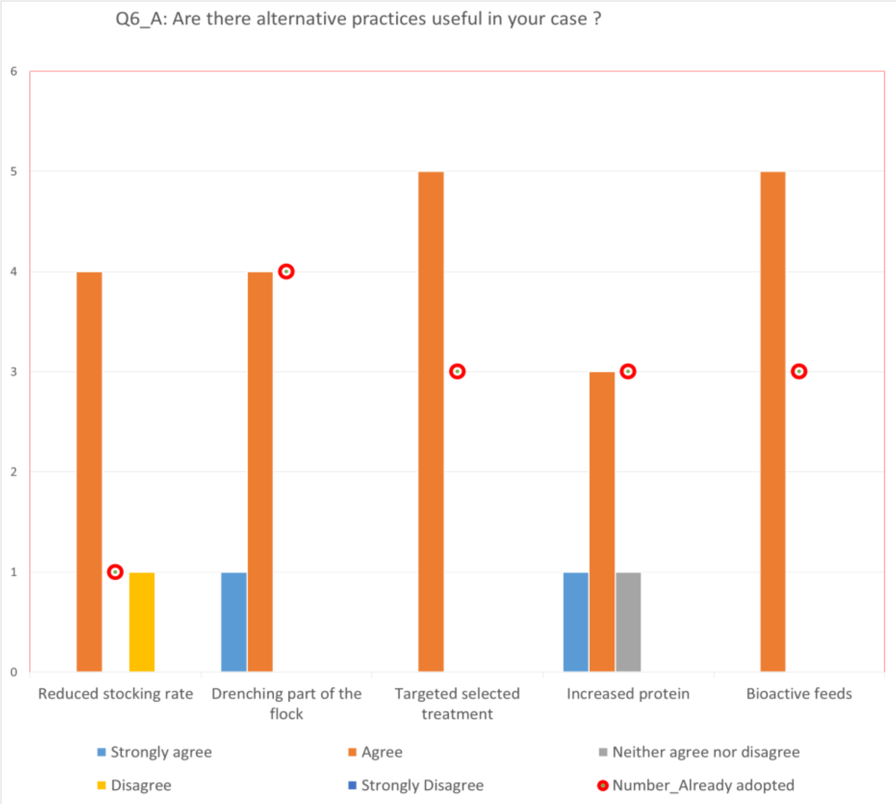

Figure 21 Usefulness of alternative GIN control practices

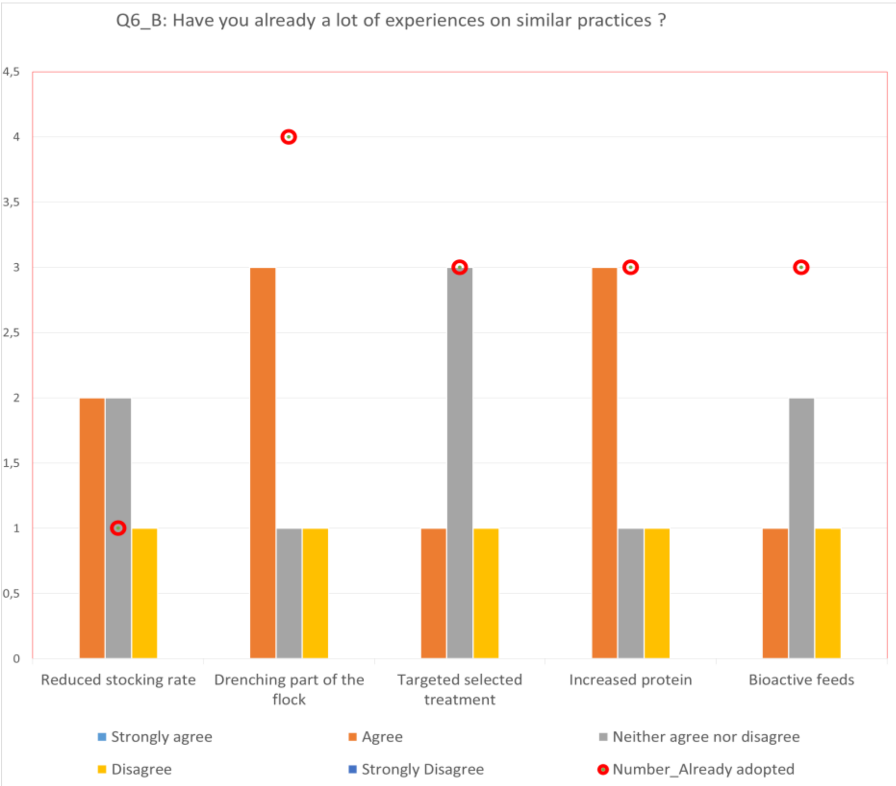

Figure 22 Experiences on similar practices

3.2.4.2 Barriers

Two general barriers to innovation uptake were expressed by farmers in the workshop:

- "There is a problem with policy financial support as this is basically the same rules for all, but every farm is different. There is a need for more flexibility. When the level of support is high, people rather try to maximise the support rather than doing what is right for their farm".
- The strategy of "increased protein" is not well considered because of the cost. It was also highlighted that this is not really an alternative anymore as farmers already tried to increase feeding as an approach.

3.2.5 Importance of recent GIN control practices

5 alternative practices were considered (to varying extents) throughout the workshop: (1) lower stocking rate, (2) drenching only one part of the flock, (3) implementation of targeted selected treatment, (4) increased protein and (5) the use of bioactive feeds.

Table 8 indicates the score of importance of these different alternative practices based on the ranking made by farmers. The decrease in stocking rate as well as the implementation of targeted selected treatment and use of bioactive feeds were considered as the most important alternatives by farmers.

This ranking might be partly explained by the different barriers and social factors to innovation uptake; but this remains ambiguous. The practices consisting of lowering the stocking rate and using bioactive feeds are strongly in line with the beliefs and values for farmers (moderately agree for TST). Lowering the stocking rate and implementing TST do not require an extensive involvement from farmers contrary to the use of bioactive feeds. The practice consisting of lowering the stocking rate enjoys strong evidences on its potential benefits; but this is less evident for TST and the use of bioactive feeds. Furthermore, the effectiveness of the different practices does not seem to have played a role in that ranking. In fact, farmers did put greater emphasis to potentially promising future practices rather than to current ones.

N°	Alternative	Score of importance	Comments
1	Lower stocking rate	0,33	
2	Targeted selected treatment (TST)	0,33	
2	Use of bioactive feeds	0,33	
3	Drenching part of the flock	0	*It is currently an important practice, not an alternative for the future*
4	Increased protein	0	

Table 8 Importance of GIN control practices in Scotland

4. General Discussion & Conclusion

<u>**Goat system**</u>:

- In general it was quite difficult for farmers to make an assessment of the model results given the high complexity of goat farming systems and the fact that variables cannot be easily isolated. This is particularly true for modelling the effects of parasites on the growth rate and level of production. There was no evidence from farmers on whether keeping kids indoor is likely to increase their growth rate or not. There is also no clear evidence from farmers on whether the alternative GIN control strategies modelled are influencing the level of production. In particular, no farmer could confirm that the GIN control practices tested are increasing the level of production.
- It was also difficult for farmers to estimate the economic impacts of GIN control practices that were not modelled but that they consider as important. In Toulouse, the practices of genetic selection (for parasite resistance) and of reseeding pastures regularly were difficult to assess because of the absence of control group. In Valence, the practice of reducing the possibility of parasite build up on pasture, as well as the use of essential oils and fresh oak leaf were difficult to assess as they are more preventative than curatives strategies. Also, farmers who tested these practices highlighted that they have not undertaken controlled faecal egg measurements, making it difficult to estimate the effect. That said, farmers envisage the need to do such testing and are calling for more systematic experiments.
- Due to the changes in milk withdrawal period, a 5’000€ (41€ per goat) increase in the annual gross margin was calculated. However, in more details: an increase in the treatment cost of 135.21 euros (negligible); decrease in the milk withdrawal cost by 7694.01€ (as the Fenbendazole is not used anymore); increase in the labour cost of 2’063 € (additional monitoring). Without the change in withdrawal periods, there would be a 2198€ increase in costs.
- Changing the pasture system was considered as the most important GIN practice as an alternative to anthelminthic treatment.
- Most important objectives of farmers are of economic nature. Particular attention is paid to the revenue and to the system resilience and viability. All GIN control practices lacking positive of economic impacts were not considered positively by farmers in workshops (e.g. non-access to pasture for kids).
- GIN control practices were also more or less considered depending on the social factors and barriers to adoption. Particularly, the practice “non-access to pasture for kids” proves to face quite some limitations according to the questionnaire on social factors filled by farmers in workshops, and was not considered as a very prominent strategy in the end (bad ranking). Limitations faced with this practice are as follows: (1) problem of efficiency; (2) not in line with farmers’ values and beliefs; (3) not easy

to understand; (4) low level of adaptability; (5) low influence of the social context for adoption; and (6) not easy to implement.

- That said, although the strategy of reseeding pasture is not easy to test according to farmers (requires an extensive involvement), it was ranked as the most prominent alternative strategy. Thus, labour might not be such a big issue. The ranking was mainly driven by future perspectives in terms of economic gains.

Sheep system:

- It was in general quite difficult for Scottish farmers to make an assessment on the model results given the high complexity and diversity of sheep farming systems and the fact that variables cannot be easily isolated. There seems not to be clear evidence whether the alternative GIN control strategies tested in the model are influencing the level of production.
- An increase of almost 12£ in the annual gross margin in lowland system and 288£ in upland system was calculated. This is due to a slight decrease in the cost of drenching (reduced number of doses applied).
- The implementation of targeted selected treatment and the use of bioactive feeds were considered as the most important (prominent) alternatives by farmers.
- The most important objectives of farmers are the economic viability and system resilience.
- Whether GIN control practices were more or less considered depending on the social factors and barriers to adoption is unclear. The practices consisting of lowering the stocking rate and using bioactive feeds are strongly in line with the beliefs and values of farmers. The effect of the labour and effectiveness criterion in considering GIN control practices is unclear. The practice consisting of lowering the stocking rate enjoys strong evidences on its potential benefits; but this is less evident for TST and the use of bioactive feeds. In fact, farmers did put greater emphasis to potentially promising future practices rather than to current ones.

Overall, the modelling and farmer feedback showed that control of GIN needs to be farm specific, to suit the individual characteristics of both the farm but also the beliefs of the farmer. The extension of withdrawal periods combined with resistance issues in France have led to the adoption of TST by some farmers, but others are less convinced of its efficiency. The farmers in Scotland seem to have adopted multiple strategies such as use of arable land and mixed grazing to keep GIN levels from severely affecting their profits. However, the diversity of opinions and calls by the French farmers in particular for more trials, shows there is still further work to understand this problem and develop more effective, sustainable solutions.

Reflection on the approach

A handbook was developed to provide researchers and workshop organizers with a structured approach in order, in a participatory manner, to cautiously address and analyse factors of innovation uptake, barriers to innovation, economic impacts of diverse alternative GIN control practices, and likelihood of adoption of these innovations. This structured approach comprises 8 steps and was inspired from the Structured Decision Making (SDM) approach. This iterative approach allowed the identification of farmers' objectives, the analysis and weighting of these objectives, as well considering the different GIN control practices from a social and economic standpoint. That said, the implementation of that approach also faced some limitations. It appeared that the duration of the workshops was a bit too long to keep farmers' attention high until the end. Particularly, the questionnaire on social factors to innovation uptake (in step 4) was probably a too long and may also be merged with the study on socio-economic barriers to adoption of GIN control practices. Furthermore, although the reflection on the general objectives of farmers proved to be useful to guide them towards suitable alternatives to them, and for us to better understand drivers to adoption; the process could be a bit less "academic" to make the discussion more exciting to farmers. In other words, this part could take more the form of a general discussion. It could then be analysed using tools for discourse analysis. MAXQDA is an example of software that can be used to that purpose. Such software allows insights into discourses e.g. by counting the number of times some keywords are stated out. This then facilitates the evaluation and interpretation of the discourses considered. The other parts of the workshop could also be examined using discourse analysis.

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