ROADMAP

Rethinking of antimicrobial decision-systems in the management of animal production

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Pathway and scenarios to ensure impact of ROADMAP initiatives

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About the ROADMAP research project

The overall aim of ROADMAP is to **foster transitions towards prudent use of antimicrobials (AMs) in animal production in different contexts to manage antimicrobial resistance (AMR). Prudent antimicrobial use (AMU) will be achieved by enhancing antimicrobial decision-systems along the food and drug supply chains.** ROADMAP will focus on supporting animal health and welfare through prevention and health promotion actions.

AMR is recognized as a significant threat to global public health and food security. Overuse and improper use of AMs in many parts of the world contribute to the emergence and spread of AMR. Although human and animal health require AMs, it has been estimated that two thirds of the future AMU growth worldwide will be in animal production. Improving the management of AMU in farm animals is therefore a critical component of dealing with AMR and optimizing production in the livestock sector. Nevertheless, the variety of contexts of AMU in the livestock sector is a major challenge to managing AMR. **There is no "one-size-fits-all" solution to improve AMU and strategies must be contextually developed** (for instance, strategies used in the Danish pig industry are difficult to adapt and adopt in the French free-range poultry farming). Successful solutions must be combined and tailored to the production systems and the social and economic context in which they operate.

ROADMAP will meet three general objectives, in line with the EU AMR Action plan: i) **Rethink AM decision-systems and animal health management**; ii) **Develop options for encouraging prudent AMU in animal production**; iii) **Engage all actors in the food and drug supply chains in fostering a more prudent use of AMs.**

Project consortium

Part. N°	Participant organisation name (acronym)	Country
1	Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (INRAE) **	France
2	Association de coordination technique agricole (ACTA) ***	France
3	Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) **	France
4	University of Liverpool (ULIV) *	United Kingdom
5	Cardiff University (CU) *	United Kingdom
6	James Hutton Institute (HUT) **	United Kingdom
7	Alma Mater Studiorum - Università di Bologna (UNIBO) *	Italy
8	Aarhus Universitet (AU) *	Denmark
9	Eigen Vermogen van het Instituut voor Landbouw en Visserijonderzoek (EV-ILVO) **	Belgium
10	Research Institute of Organic Agriculture (FiBL) **	Switzerland
11	Stichting Wageningen Research (WR) *	Netherlands
12	Swedish University of Agricultural Sciences (SLU) *	Sweden
13	Southern Agriculture and Horticulture Organization (ZLTO) ***	Netherlands
14	European Forum of Farm Animal Breeders (EFFAB) ****	Netherlands
15	Fundacion Empresa Universidad Gallega (FEUGA) ****	Spain
16	Dierengezondheidszorg Vlaanderen (DGZ) ***	Belgium
17	INRAE Transfert (IT) ****	France

** Universities/veterinary schools*
*** Research institutes specialized in both fundamental and applied agricultural and veterinary sciences*
**** Public and private advisory services Organisations*
***** Knowledge transfer and Innovation organisations*

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List of acronyms and abbreviations

AB	Antibiotics
ABU	Antibiotic use
ALEA	Animal-level exposure to antibiotics
AM	Antimicrobials
AMCRA	Centre of Expertise on Antimicrobial Consumption and Resistance in Animals (Belgium)
AMR	Antimicrobial resistance
AMR-PMP	AMR-Progressive Management Pathway
AMU	Antimicrobial use
ANVOL	Broiler poultry interprofession (France)
ANSES	Agency for Food, Environmental and Occupational Health & Safety (France)
BVK	Professional association for the Belgian veal sector (Belgium)
CIAs	Critically important antibiotics
CNR-AR	National Reference Center for Antibiotic Resistance (Italy)
DGAL	General Directorate of Food of the Ministry of Agriculture and Food (France)
DGSAF	General Directorate of Animal Health and Veterinary Drugs (Italy)
DGZ	Animal health care Flanders (Belgium)
ESVAC	European Surveillance of Veterinary Antimicrobial Consumption
EMA	European Medicines Agency
EVR	Electronic Veterinary Recipe system (Italy)
FAMHP	Federal Agency for Medicine and Health Products (Belgium)
HPCIAs	Highest priority critically important antimicrobials
IFIP	The pork institute (France)
INAPORC	National pork interprofession (France)
INRAE	The National Research Institute for Agriculture, Food and the Environment (France)
ITAVI	The Technical Institute of Aviculture (France)
IZS	Experimental Zooprophylactic Institute (Italy)
KOM	Kick-off meeting
LAAAF	Law for the future for agriculture, food and forestry (France)
LL	Living laboratory
MARD	Ministry of Agriculture and Rural Development (Vietnam)
MIC	Minimum inhibitory concentration
NAP	National Action Plan (Vietnam)
PGS	Participatory guarantee system (Vietnam)
PNCAR	National One Health action plan on AMR (Italy)
SNGTV	National society of veterinary technical groups (France)
SNVECO	National Union of Veterinary Consultants (France)
VCIAs	Veterinary critically important antimicrobial agents
VietGAHP	Vietnam Good Animal Husbandry Practices

1 Summary

This deliverable present results for Task 6.3 “ex-ante impact assessment” which was conducted in five countries (Belgium, Denmark, France, Italy and Vietnam) and aims at improving the construction of ROADMAP initiatives toward prudent antimicrobial use (AMU) by designing them in a strategic and participatory manner and laying out the mechanisms through which impacts will be generated.

Task 6.3 activities were conducted between October 2020 and June 2022 through personal interviews, surveys and workshops. The process of ex ante impact assessment involved building a desired vision for the future, identifying problems preventing the desired impacts from happening, and designing strategies to address these problems. Activities sometimes underwent delays because of Covid-19-related restrictions but led to the construction of a large variety of impact pathways for ROADMAP initiatives.

In Belgium, the main initiative was centered around an action lab to better establish the advisory role of veterinarians in the pig sector, whereas in Denmark a lot of efforts were put into discussing the link between AMU and antimicrobial resistance (AMR) in a context of very low AMU and progressing towards mutual realisation and improved communication/sharing of experience. In France, an action lab will be set up to build combined indicators that report in a simple and optimal way information about the health of animals, their well-being, the use of antibiotics and bacterial resistance to antibiotics. Activities in Italy focused on updating the guidelines on the use of antibiotics in pig farms elaborated by the public health services of the Emilia-Romagna region, whereas stakeholders in Vietnam worked towards establishing training/awareness-raising programs for both animal/drug professionnals and consumers.

The desired impacts these activities aimed to contribute to shared some common grounds: decreased or improved AMU, improved animal health and welfare, maintained (or increased) incomes for farmers and veterinarians, reinforced resilience of animal production and improved communication towards consumers. The next step of WP6 activities will be to perform a transversal analysis of these impact pathways and establish generic recommendations for broader, long-lasting and context-adapted transition pathways towards prudent AMU.

2 Introduction

The ROADMAP project aims at developing interventions/solutions for encouraging prudent antimicrobial use (AMU) in animal production. The objective of the ex ante impact assessment process (developed under WP6) is to improve the construction of interventions and solutions by designing them in a strategic and participatory manner and laying out the mechanisms through which impacts will be generated.

The ex ante impact assessment method we developed, based on the ImpresS[1] methodology, is a participatory intervention-building approach inspired by existing theorical frameworks. It aims to elucidate a collective and shared vision of an intervention logic through the construction of an impact pathway underpinned by a theory of change. The impact pathway describes the underlying program theory of the intervention by elucidating the causal links between resources mobilized by the intervention (inputs), the intervention's products (outputs), the changes in practices, behavior and interactions for the actors associated with the use, adaptation or transformation of these outputs (desirable changes or outcomes) and the impacts to which these outcomes contribute in the long term.

Training and workshops on ex ante impact assessment were organised at each ROADMAP General assembly meetings (in 2020, 2021 and 2022) and involved the five countries involved in Task 6.3: Belgium, Denmark, France, Italy and Vietnam. There were different phases in the process during which case-study leaders had to:

- **Delimit the perimeter of the case study**: livestock sector (poultry, pig, dairy, calf), type of production (organic, conventional) and eventually a geographic or an organisational perimeter (for e.g. a given cooperative);
- **Establish an initial assessment**: gather information about the legislative framework and the current state of AMU in the targeted animal production sector, as well as the different past and on-going programs aimed at optimizing AMU;
- **Identify the stakeholders**: this has been done through the stakeholders' mapping, in synergy with activities done for WP1;
- **Identify the possible desired impacts of stakeholders**: this was achieved through interviews, surveys or workshops with stakeholders. Whenever possible, these activities were conducted jointly with other activities for WP2, WP3 and WP4 to avoir oversollicitating stakeholders;
- **Build a narrative**: construct a shared vision and a mobilization of actors towards a common goal, identify problems preventing this desired vision, and build strategies/activities towards addressing some of these problems;
- **Summarise** the plausible impact narrative through an **impact pathway diagram**
- **Start thinking about indicators** that will be used to monitor outputs, outcomes and impacts.

Activities were conducted between October 2020 and June 2022 in the five countries, sometimes with delays owed to Covid-19-related restrictions. They led to the construction of context-specific impact pathways detailing scenarios for the initiatives identified by stakeholders to reach their desired common vision.

[1] https://impress-impact-recherche.cirad.fr/

3 ROADMAP initiative in Belgium

Course of the work

There were two case-studies in Belgium (pig and veal calve) and activities were synergized between WP1, WP3, WP4 and WP6 for more efficiency. For both case studies, the relevant stakeholders were identified through key informant interviews that were performed in the context of Task 1.4. These stakeholders were invited to participate into the kick-off meeting (KOM) which gathered 56 participants from 44 organizations and was held online in October 2020 due to the covid-19 situation.

Living Labs

The format of the Living Labs was determined by the participants, who preferred monthly online meetings of +- 1.5 hours. A total of four online living labs (December-March 2021) were organized for each case study and about 20-25 participants from different organisations (see Tables 3.1 and 3.2) took part to each meeting. During the first living lab of each case study, the results of the KOM were further discussed and a problem tree was built by the participants. This tree was further developed during the following living labs. Once the problem tree was completed, a vote was held in both case studies to determine which parts of the problem tree would be addressed during the action labs.

Table 3.1: Overview of the different meetings that were held in the context of WP6

Meeting	Date and place	# Participants	Topic discussed
Kick-off meeting	09/10/2020 - Online	56	Presenting Roadmap project & LL
1st LL Pig sector	15/12/2020 - Online	25	Designing problem tree
1st LL Veal calve sector	09/12/2020 - Online	20	Designing problem tree
2nd LL Pig sector	26/01/2021 - Online	20	Designing problem tree
2nd LL Veal calve sector	26/01/2021 - Online	23	Designing problem tree
3rd LL Pig sector	25/02/2021- Online	21	Designing problem tree
3rd LL Veal calve sector	25/02/2021- Online	19	Designing problem tree
4th LL Pig scetor	30/02/2021 - Online	21	Finalising problem tree & setting up AL
4th LLVeal calve sector	30/02/2021 - Online	17	Finalising problem tree & setting up AL
Intro AL Pig sector	27/04/2021 - Online	14	Setting up AL
Intro AL Veal calve sect.	27/04/2021 - Online	15	Setting up AL
1st AL with farmers (pigs)	21/05/2021 - Online	10	Defining possible interventions
1st AL with vets (pigs)	21/05/2021 - Online	7	Defining possible interventions
1st AL veal calve sector	23/06/2021 – Person	7	Writing project proposal
2nd AL With vets (pigs)	14/09/2021 - Online	5	Defining possible interventions
One jear ROADMAP	08/10/2021 - Online	40	Presenting results of the LLs
2rd AL veal calve sector	17/11/2021 - Online	9	Writing project proposal
3rd AL veal calve sector	25/11/2021 - Online	9	Writing project proposal
3rd AL with vets (pigs)	08/12/2021 - Online	8	Defining possible interventions
4th AL with vets (pigs	28/01/2022 - Online	6	Presenting an approach for the AL

Table 3.2: Overview of the different types of stakeholders who participated to the living labs

TYPE	ORGANISATION	CALVES	PIGS
Industry	Pharmaceutical companies	√	√
	Animal feed companies	√	√
	Veterinarians	√	√
	Integrators	√	
	Retail	√	√
Government	BE medicine agency	√	√
	BE food safety agency	√	√
	Flemish agri & fisheries dep.		√
NPO	Labels	√	√
	BE knowledge center for AMR/AMU	√	√
	BE Feed association		√
	BE meat federation	√	√
Professional organisations / syndicates		√	√

Pig action labs

For the pig case study, which is being conducted in depth (level 2), several solutions/actions were discussed by the participants. During the intro action lab, it was decided to merge some of these solutions in order to end up with two action labs: one to better establish the advisory role of vets and one to demonstrate the advantages of preventive and alternative methods over the long run.
Stakeholders were free to choose which action lab they wanted to participate in. However, veterinarians were advised to seek participation in the action lab focussing on advice, while farmers were advised the opposite. For each option, an initial action lab was held in May 2021 to discuss the purpose of the group, to define a title, and to plan the next steps. After this, it was decided to stop the action lab on the demonstration of the advantages of preventive and alternative methods over the long run as farmers did not want to participate anymore due to the bad economic situation of the pig sector. For the action on the establishment of the advisory role of vets, three additional action labs were organised before a concrete strategy was being implemented and tested on farms in April 2022.

Veal calve action lab

Since the case study on veal calves will not be examined in depth (level 1), there were no means to test possible solutions on farms. However, participants were offered the option of writing a project proposal to address some of the issues identified during the living labs. A small group of participants expressed interest in doing so and decided to meet regularly to discuss ideas for a project proposal. Additional stakeholders were involved in the process and several bilateral and group meetings were organised. In total, three group meetings were organised, one in person and two online. Ultimately, several parties decided not to submit the project because a more international approach was more desirable than a local one. The main reason for this was that some parties might have to invest more, but would still have to compete in an international market with few opportunities to sell at a higher price.

3.1 Initial assessment

Over the past decade, Belgium has made great efforts to reduce the use of antimicrobials in animal husbandry. To this end, two main approaches have been followed: the creation of national databases to monitor the sales and use of antimicrobials, and the establishment of two strategic plans with clear reduction targets. Regarding the first approach, the **BelVet-Sac database** was first established to provide for the annual collection and analysis of sales data of antimicrobials for veterinary use under the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project, which started in 2010. Reports based on the collected data are published annually. In 2017, the **Sanitel-Med database** was launched by the Federal Agency for Medicines and Health Products (FAMHP) to collect AMU data at the species level. It is mandatory for producers of poultry (laying hens and broilers), pigs and veal calves to have all antibiotics administered or dispensed recorded by the farm veterinarian (Royal Decree of 31/01/2017). Both the farmer and the company veterinarian receive benchmarking reports of their AMU. Regarding the second approach, several actors of the Belgian animal health system, such as representatives of the unions of livestock farmers and veterinarians, academia and feed and pharmaceutical associations have created the Centre of Expertise on Antimicrobial Consumption and Resistance in Animals (AMCRA), with the aim of reducing the use of antimicrobials in animals by providing advice, guidance and awareness to veterinarians, livestock farmers and the general public. To date, AMCRA has produced two strategic plans, **AMCRA's Vision 2020** and **AMCRA's Vision 2024**. Both plans consist of main objectives and operational objectives to help achieve the main objectives. The plans were translated into covenants, which clarify the division of tasks in the context of the commitments to be made to achieve the strategic plan's objectives, and have been signed by AMCRA, the Ministers of Health and of Agriculture, and various actors involved in the production of beef cattle.

Flemish pig sector

The Flemish pork sector has also taken initiatives to reduce the use of antibiotics. In 2000, the non-profit organization Belpork was founded with the aim of promoting the quality of Belgian pork in a sustainable way. The organization managed the Certus quality label which guarantees strict standards, controls and traceability. In 2014, Belpork launched the “AB-register” database and all producers approved within the Certus quality label, which at the time represented about 50% of Flemish pig farms (and about 70% in 2019), were required to register all antibiotics administered or administered by the suppliers of the products. Belpork collaborated with AMCRA's data analysis department to analyze AMU data, and Certus producers received a biennial benchmarking report that compared the farm's BD100, or number of days of antibiotic treatment over 100 days, to two BD100 cut-off values (the 50th and 90th percentile of frequency distributions) to determine whether the producer was a low, an above-average, or a large antibiotic user. Later, the quality system for poultry farmers, Belplume, and the quality label for Flemish dairy farms, IKM Flanders, also joined the “AB register”, requiring their participants to record antibiotic use (ABU). These databases are now linked to the Sanitel-Med national database and AMCRA is still in charge of benchmarking reports.
In 2020, fattening pigs and weaned piglets were the animal categories with the largest mass of antimicrobials used (67% of the tons used) in Belgium, as described in the latest BelVetSAC report.

Flemish veal calves sector

The Belgian veal calf sector is a highly integrated production. Since 1996, almost all production has been controlled according to the very strict specifications of the non-profit organization BVK (Beroepsvereniging voor de Belgische Kalfsvleessector) and compliance is verified by the independent external control SGS-Agrilab NV. BVK also has its own database in which antimicrobial use is recorded and AMCRA is responsible for benchmarking reports. In 2020, the industry reduced its AMU by 218.33% compared to 2018, probably as a result of the "10 step action plan" adopted by the industry. Despite these tremendous efforts, veal calf farms have the highest baseline antimicrobial use and a BD100 (the number of treatment days at 100 days based on the total amount of antimicrobials used by species and the total mass of at-risk animals by species) of 22.7, which is 3.5 times higher than pigs (6.5) and 4 times higher than poultry (5.6), as described in the 2020 BelVetSAC report.

Achieved reductions

Following the different initiatives taken at sector and national levels, the pig, poultry and veal calve sector managed to reduce their AMU use by more than 40% between 2011 and 2020. Unfortunately, this was not enough to achieve the objective of AMCRA's vision 2020 (i.e. a 50% reductions) and further efforts will be necessary to reach the new reduction objective stated in AMCRA's vision 2024 (i.e a 65% reduction of AMU).
Despite the efforts of the livestock production sector, Belgium still has a substantial AMU compared to other EU countries (ca. 130 mg/PCU in 2017 while the EU Median is 61 mg/PCU). A summary of the latest results can be found in this presentation or in the BelvetSAC reports available here.

3.2 Problem(s) addressed by the initiative

As stated in the previous paragraph, the Centre of Expertise on Antimicrobial Consumption and Resistance in Animals (AMCRA) developed two action plans with concrete actions to reduce AMU in Belgium's main food producing species. The latest strategic plan, AMCRA's vision 2024 is composed of 4 key objectives and 9 action points. The key objectives are:

- Species-specific reduction targets at the farm level and a maximum of 1% of users in alarm zones by 2024
- Total antibiotic use will reach the European median by 2024
- Maximum use of 1 mg colistin/kg biomass by 2024
- Reduction in the use of medicated feeds containing antibiotics

As the action plan was recognized by AMCRA, the government and a lot of other actors such as farmers' organisations, the pharmaceutical industry, the feed industry, veterinarians' organisations, … it is safe to state that its objectives and action points define the general vision for the future and desired impacts for the pig and veal sector. During the living labs, all the stakeholders agreed that farmers and veterinarians should use antimicrobials as little as possible and as much as necessary without compromising animal welfare and their incomes.

Identification of problems preventing this desirable future from happening in the pig case study

For the Belgian pig sector, the following main causes for antibiotic use were identified (Figure 3.1):

a. *Poor animal gut health*
For this issue, the following 5 root causes were identified : genetics of animals, vertical transmission of pathogens from sow to piglet, poor quality of raw materials, poor feed intake after weaning, adverse effects of AB on intestinal health (see blue branch in Figure 3.1). In addition, a link was made with poor biosecurity, which was in turn attributed to a poor farm management.

b. *Poor farm management*
Many factors that may influence farm management were discussed during the LLs (see grey branch in Figure 3.1). **A 1st main reason** was the difficulty for veterinarians to give advice because of farmers' perception of results (delayed vs. tangible), other advisors giving "free advice", and current legislation not strenghtening the farm vet's advisory role. This difficulty for veterinarians to assert their position as advisors was also related to the problem that farmers sometimes receive conflicting advice from different actors and that it is not always easy to get these actors to work toward a common goal. **A 2nd major reason** appeared to be the lack of monitoring of farm parameters, which was due to a lack of time and of financial and digital resources. **A 3rd reason** was related to alternative medicines. Antibiotics are stil preferred to alternatives as they are more efficient, deliver immediate results and are best known by the vets and farmers. Regarding this last point, it was determined that this lack of knowledge of alternatives is due to the oversupply of such products, the lack of information to allow comparison between the products, the limited amount of scientific knowledge on efficiency and the small economic interest for vets, although it was pointed out that this last reason would have little influence since most veterinarians try these products but often obtain variable results. Finally, the above mentioned reasons were also related to the lack of incentives for farmers to adapt their farm management and/or to explain farmers' fear of change.

c. *Economic reasons*
The economic reasons for the high ABU included the fact that vaccines are considerably more expensive than antibiotics, that selling prices of animals are very low and finally, that vaccines are perceived to be less attractive than antibiotics from an economic point of view (yellow branch in Figure 3.1). This last point was further supported by the fact that antibiotics treat a larger range of pathogens than vaccines and that piglet farms will not enjoy the benefits of vaccination as these are only seen at the fattening stage. In addition, there is also a limited number of (economic) studies on the long-term effects/benefits of vaccines.

d. *Societal pressure*
This last cause is interrelated with an economic reason (pink and yellow branches in Figure 3.1). Due to societal pressure regarding animal welfare, animals with small defects (e.g. bitten tail) are not accepted by the slaughterhouses anymore. These animals are then often treated with antibiotics in the hope that they will become fit enough to be sold and go to slaughter. In reality, this is rarely the case, and such animals end up being euthanized. This problem is an indirect consequence of the general public's unfamiliarity with agricultural practices, which results in requirements that are difficult to combine with current production models and can have unexpected negative results. Another example includes the general public's confusion regarding antibiotic use and antibiotic residues in meat.

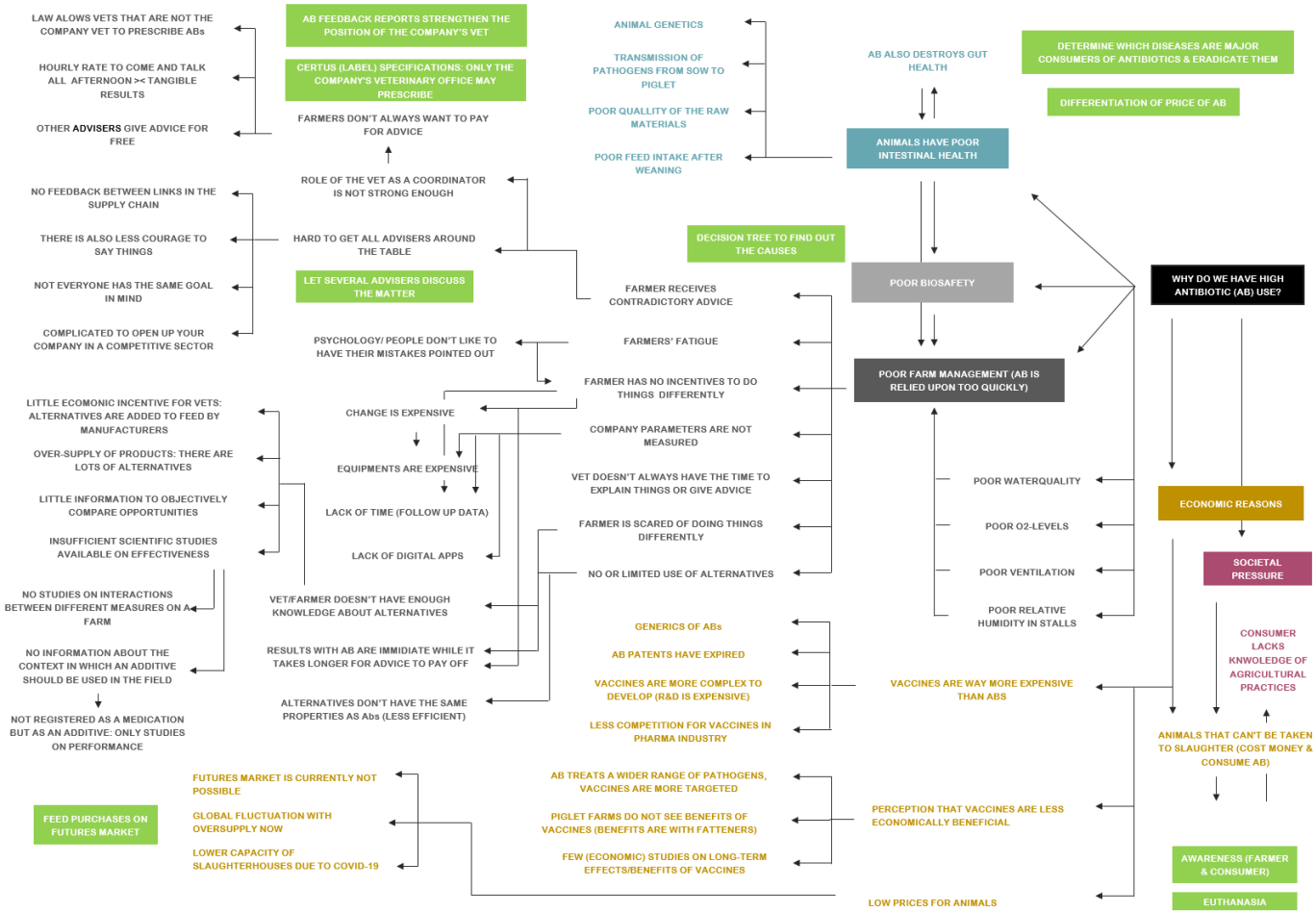

Figure 3.1: Problem tree for the pig sector developed during the living Labs according to the Ex-ante impact analysis method

Selected problems for the initiative for the pig case study

For the pig case study, the original goal was to have two initiatives that would be developed in action labs. One initiative would focus on identifying the role of the veterinarian as advisor and developing a decision tree that could help farmers and veterinarians in their choices regarding AMU. For this, the following changes would need to be implemented:

- Veterinarians should develop farm health plans and guide the farmers through the process by providing feedback with written reports or via an app. In addition, vets should also provide health passports (e.g. app).
- Farmer should test the animals in order to provide the health status and should be willing to pay the veterinary for advice.

The second initiative would demonstrate that the use of preventive and alternative methods (e.g., vaccination) pays off in the long run and would raise awareness about animals that cannot go to the slaughterhouse. Therefore, the following changes should be made:

- Farmer: Should measure key farm parameters in order to see whether preventive and alternative methods improved animal health
- Veterinarian: Should monitor the measured parameters with the farmer + raise awareness regarding the set standards of the slaughterhouse and offer alternatives (i.e. euthanasia).

To decide how this would be done, action labs were organised for both initiatives. An initial action lab was held in May 2021 to discuss the purpose of the group, to define a title, and to plan the next steps. After this, it was decided to stop the action lab on the demonstration of the advantages of preventive and alternative methods over the long run as farmers did not want to participate anymore due to the bad economic situation of the pig sector. For the action on the establishment of the advisory role of vets, three additional action labs were organised before a concrete strategy was being implemented and tested on farms in April 2022. This resulted in a clear action plan where different approaches would be tested to reduce AMU in weaned piglets. First farmers that want to reduce their AMU should be recruited and a first meeting will be organised with the farmer, DGZ (Animal Health Services Northern-Belgium, & also partner with EV-ILVO within ROADMAP) and the herd veterinarian. During this meeting, the motivation of the farmer, the farms characteristics, … is retrieved. At that first meeting, the farmer, veterinarian and DGZ decide which intervention from the list in Table 3.3 is most appropriate for the farm. For every intervention, different analyses would be performed to monitor the progress and demonstrate the effectiveness of these methods (Table 3.3).

Table 3.3: Overview of the different interventions and the corresponding analyses

Intervention	Analysis
Optimisation of colostrum management	• Testing colostrum intake • Testing manure for prevalence of pathogens
Optimisation of cleaning and disinfection	• Rodac plates • Testing manure for prevalence of pathogens
Combination of colostrum and C&D optimisation	• Testing colostrum intake • Testing manure for prevalence of pathogens • Rodac plates
Advisory role of the vet	• Testing manure for prevalence of pathogens

It was opted to include different diagnostics ('analysis') to assist the different interventions and provide handles to farmers and veterinarians to better evaluate if AM are needed or can be reduced. Testing the intake of colustrum may demonstrate business/farm blindness related to the management at the nursery unit, impacting the immunity status of the grown piglets. This is done by quantifying and comparing antibody titres in sow and piglets against *Erysipelothrix rhusiopathiae*. Rodac plates (Replicate Organism Detection And Counting) can be used for microbiological control of all surfaces evaluating the efficiency of cleaning and disinfecting protocols, hence the microbiological contamination load of the stables. Appropriate diagnostics related to which gut pathogens circulate (through microbiological testing of faeces samples), is a prerequisite to alter habits to control intestinal pathogens at the herd.

Identification of problems preventing desirable future from happening in the veal calve case study

For this case study, the following main causes for a high antibiotic use were identified (Figure 3.2):

a. *High cross-contamination rate*
It was determined that antibiotics are used because of large differences in the immunity status of the veal calves arriving at the sorting centers (see blue branch in Figure 3.2). These differences can be attributed to the following causes: different genetic background (dairy calves (red and black Holstein-Friesian), purebred double muscled Belgian blue calves and crossbreds), difficulty to vaccinate/unavailability of vaccines for certain pathogens, the fact that calves are sometimes younger than legally authorized when sold (min. 14 days), the poor treatment veal calves sometimes receive on dairy farms, the vaccination status of the dams and the feed the dams receive. With regard to the minimum age at which veal calves can be sold, a subtility in the law allows farmers to sell calves that are twice as young as they should be. Indeed, dairy producers are legally allowed 7 days to report the birth of a calf. In some cases, calf births are reported as 7 days old, which allows the farmer to sell the calf when it is 7 days old instead of 14 days old. This practice as well as the poor treatment veal calves sometimes receive on dairy farms is due to the fact that male calves are considered as a by-product of the industry and are not very profitable. Some farmers thus try to sell them as soon as possible by investing as little time and ressources as possible. In addition, dairy farmers won't perceive the benefits of vaccination of the dams with regard to the veal calves, as they will already be sold by then.

b. *Infrastructural problems*
Next, a poor biosecurity was linked to infrastructural problems (see dark grey branch in Figure 3.2) such as no cleaning of pipes, a poor ventilation, a lack of pens for sick animals, a lack of hygiene locks and a lack of compartmentization in stables. With regard to ventilation, it was stated that the farmer often has the impression that changes with regard to ventilation will be very costly (while this is not always the case) and that this often falls beyond the expertise of the vet, which is why it is not addressed.

c. *Business blindness*
The infrastructural problems were futher linked to business blindness (see light grey branch in Figure 3.2), as farmers are focussing on the animals rather than on the environment (e.g. stables) and also tend to focus only on their own business and thus do not always consider the broader picture.

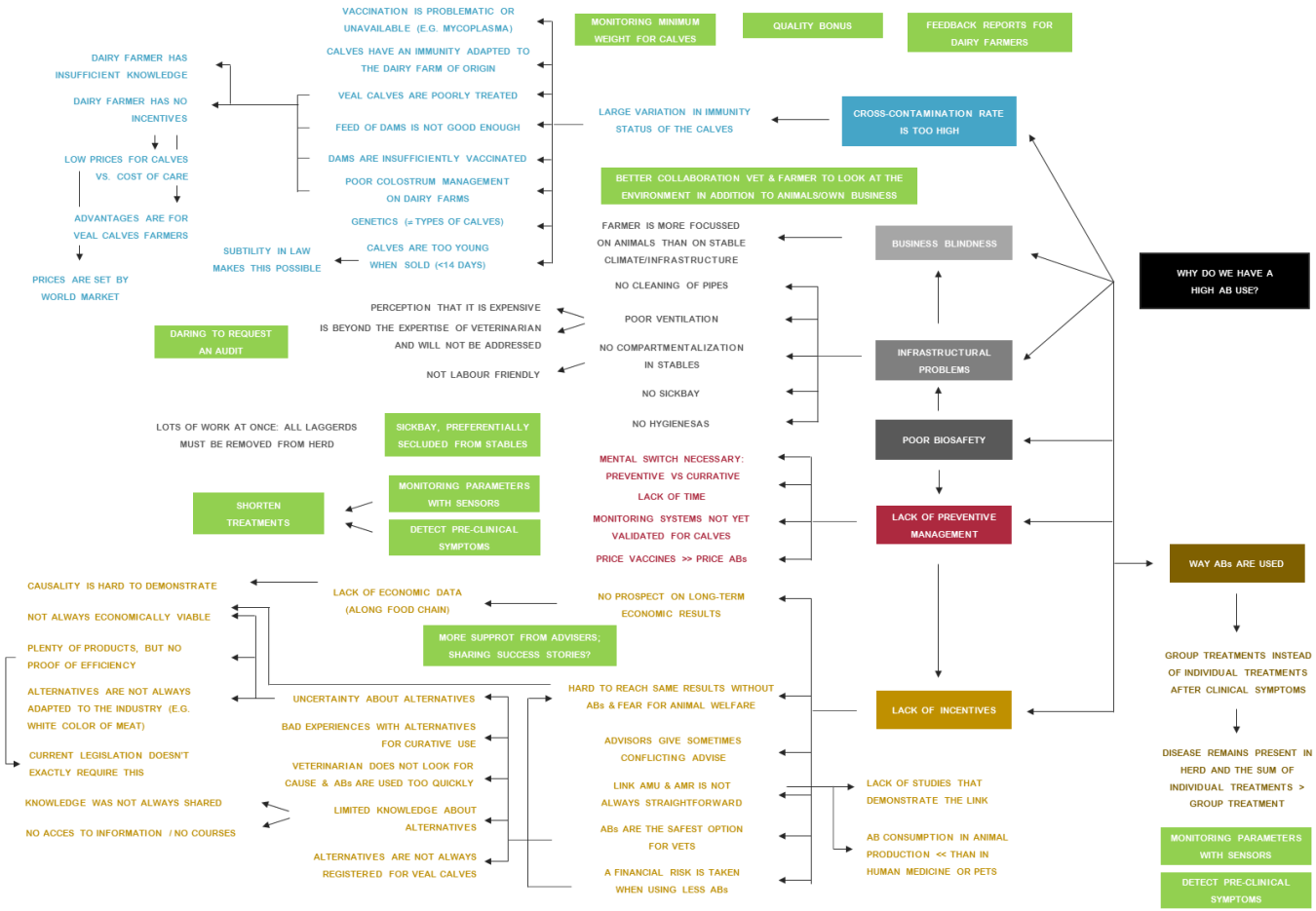

Figure 3.2: Problem tree for the veal calve sector developed during the living Labs according to the Ex-ante impact analysis method

d. *Lack of preventive management*

In addition to infrastructural problems, a poor biosecurity was also linked to a the lack of preventive management (see purple branch in Figure 3.2). Here, the main reasons were a lack of time, the fact that automated monitoring systems (e.g. sensors to monitor behaviour) are not validated yet for calves and the fact tat vaccines are more costly than AMbs.

e. *Lack of incentives*

Furthermore, a lack of preventive management could also be linked to a lack of incentives to use fewer ABs (see yellow branch in Figure 3.2). For this, seven underlying causes were identified:

- *No prospect on long-term results*: Because of the lack of economic data, there is very little information on whether investments in calf health could reduce costs at a later stage, allowing integrators to pay more for healthy calves. In addition to this, a lot of data is necessary to link economic changes to technical changes, making it hard to establish causality.
- *Sometimes, advisors give conflicting advice.*
- *Hard to reach same results without AB and fear for animal welfare.* Alternatives don't have the same properties as AB. They are economically not always viable and when a disease occurs, AB are what works best to treat the animals.
- *AB are the safest option for the vet.* This reason was further supported by several rootcauses, being: the fact that vets are not always looking foor the root causes and swiftly use AB, the limited knowledge about alternatives, the fact that alternatives are not registered for veal calves, the bad results that were obtained with alternatives and the uncertainty about alternatives. With regard to the latter, it was discussed that many alternatives are offered but that the effiency cannot be proven. Moreover, the alternatives are not always adapted to the requirements the white calve meat must comply to. Regarding the knowledge about alternatives, it was pointed out that courses only start to be available know and that before acquired knowledge wasn't always shared amongst different stakeholders.
- *Link between AMU and AMR is not always straightforward*. There is still limited information on the exact link between AMU and AMR and some resistances are still present while the AB are not used anymore. The AB consumption in animal production is also lower than in human medicine or pets.
- *A financial risk is taken by veterinarian and integrator.* Due to the set up of the production system a financial risk is taken when trying to use fewer antibiotics or when experimenting with alternatives.

f. *Way antibiotics are used*

Finally, the way antibiotics are used was also discussed (see brown branch in Figure 3.2). Group treatments are often applied after clinical symptoms are detected. Several vets tried to work with individual treatment but were faced with the problem that a group treatment is often still necessary as the disease has already been circulating in the herd and cannot be contained anymore.

Selected problems for the initiative in the veal calve case study

The main issue in this case study appeared to be the quality of the veal calves, as was extensively explained in the previous section. As there were no means to test possible solutions on farms in this case study, participants were presented with the idea of writing a project proposal to test some of the solutions presented during the LL. Potential outcomes of the action lab are financial ressources for a follow-up project and strengthened links between research institutes, governmental institutes and actors fom the veal calve sector. A small group of participants expressed interest in doing so and decided to meet regularly to discuss ideas for a project proposal. Additional stakeholders were involved in the process ans several bilateral and group meetings were organised. In total, three group meeting were organised, one in person and two online. Ultimately, several parties decided not to submit the project because a more international approach was more desirable than a local one. The main reason for this was that some parties might have to invest more, but would still have to compete in an international market with few opportunities to sell at a higher price.

3.3 Narrative and impact pathway of the initiative

For these initiatives to work, several inputs are needed (see Figure 3.3). A first input is veterinarians' knowledge about preventive measures , which combined with the measurement of farm parameters and pathogen prevalence (partially sponsored by the ROADMAP project), can result in clear farm-specific health plans to improve the health of animals on the farm. The expected result of this is that it will become easier to detect and resolve the underlying problems, rather than constantly treating the symptoms. This is expected to have several effects, namely helping to establish the advisory role of the veterinarian, a reduction in the number of AMUs as a direct result of more alternative/preventive approaches, and stronger and healthier animals at the various stages of production. The latter two are then expected to further contribute to lower AMU/AMR in livestock production and possibly to lower production costs for the livestock owner. During the living labs, this transition from treating the symptoms to identifying and solving underlying issues had been extensively discussed. The mains barriers to overcome here are the willingness of the farmer to pay for advice as well as the sometimes poor communication skills of the vets. To address this, the Roadmap project will sponsor vets with vouchers worth €100 euros. Farmers will also be asked how much they would be willing to pay for advice in order to try to define a correct price for the veterinarian that is acceptable for the farmer.

Second, the collaboration between the farmer, DGZ and veterinarian combined with the measurement of farm parameters and pathogen prevalence is expected to produce three different types of outputs: the demonstrated effectiveness of preventive approaches, farm-specific strategies to improve colostrum intake and farm-specific strategies to ensure clean and disinfected barns. The first output is expected to convince farmers of the efficiency of preventive approaches, and the impact of these outcomes is expected to be that the advisory role of the veterinarian is better established and that AMU decreases as a direct result of more alternative/preventive approaches, further leading to lower AMU/AMR in the livestock industry and possibly to lower production costs for the livestock owner. The second output should better enable farmers to secure sufficient colostrum uptake by piglets. Because of this, pig are also expected to be healthier in the following stages of the production, leading to a lower AMU/AMR in livestock production as well as potentially reduced costs for the farmer. Another

impact of this outcome is a reduced risk of contaminating healthy animals and a lower disease prevalence. This impact is also expected to be achieved with the third output, which should ensue in an improved stable hygiene. For the second and the third input, the challenge will mainly be to motivate farmers to take part in this. While a lot of farmer are willing to reduce their AMU, they often encounter barriers such as high costs to implement the changes, fear with regard to big changes, fatigue, lack of time and apps, … (see Figure 3.2). DGZ and the veterinarian will need to take this in account in order to define a strategy that seems feasible for the farmer.

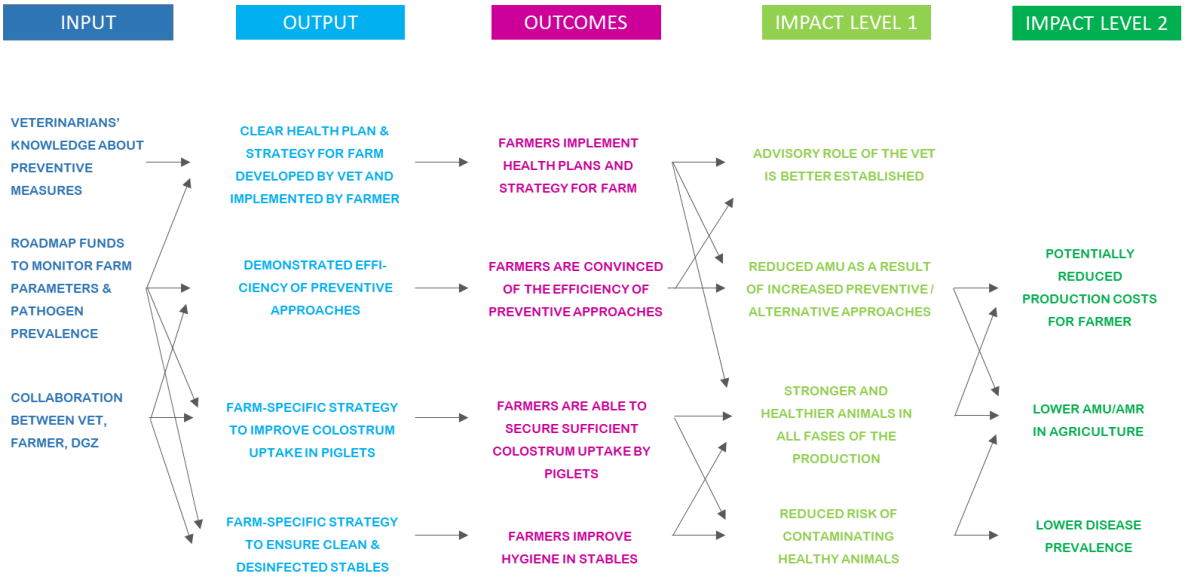

Figure 3.3: Impact pathway for the pig case study in Belgium

Veal calve case study

For the veal calve case study, several stakeholders were brought together in order to write a research proposal to apply for regional funding. The writing of this proposal was based on an older one that had not been selected for funding. The combination of scientific and tacit knowledge, as well as a better understanding of the veal calf industry, significant changes could be made to the proposal that may result in:

- Industry partners willing to cofinance the research project
- The testing of solutions that can be implemented on a larger scale
- The allocation of ressources in a more realistic way

In addition to this, this research proposal could lead to several otcomes and impacts, as shown in Figure 3.4. Unfortunately, this impact was not achieved as several partners decided not to submit the proposal.

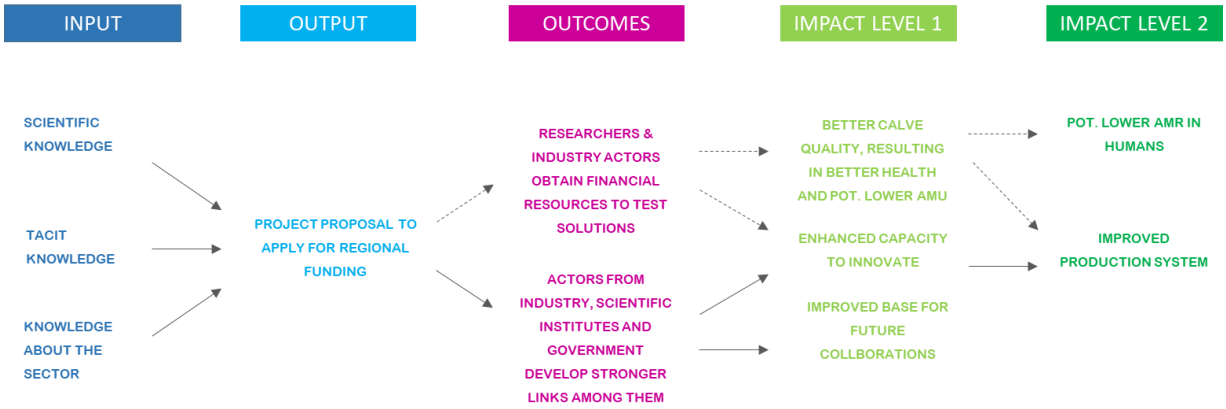

Figure 3.4: Impact pathway for the veal calve case study in Belgium

3.4 Impact indicators for the initiative

Pig case study

For the pig case study, since the different approaches aim to create farm-specific outputs, indicators to monitor the desired impacts will be determined by the veterinarian, DGZ and farmer during the first introductory meeting. While the aim is to try to monitor the progress in a standardized way, there might be some adaptations due to farm-specific conditions. Globally, the following indicators will be used to monitor the impacts (Table 3.4):

Table 3.4: Impact indicators for the pig case-study initiative in Belgium

IMPACT	INDICATOR	DATA	COLLECTED BY
Established advisory role of vet	Willingness of farmers to pay for advice	Survey with farmers taking part to the AL	DGZ
Stronger and healthier animals at all production stages	Efficacity of colostrum intake through antibody measurements in piglets and sows	Antibody titres against *Erysipelothrix rhusiopathiae* before and after intervention	DGZ, Vet, farmer
	Prevalence of pathogens in manure	Faecal microbiological analysis; Clinical records including necropsy reports	DGZ, Vet, farmer
	Farm parameters	Feed conversion, growth rate, morbidity rates	Farmer
	Evolution of AMU	Benchmarking reports	Vet, Farmer
Reduced risk of contaminating healthy animals	Prevalence of pathogens in manure	Faecal micobiological analysis	DGZ, Vet, farmer
	Farm parameters	Morbidity rates	DGZ, Vet, farmer
	Microbial contamination of stable surfaces	Microbial counts through RODAC testing plates before and after intervention/ adaptation of C&D protocol	DGZ, Vet, Farmer

4 ROADMAP initiative in Denmark

Course of the work

WP6 activities in Denmark involve a cattle Living Lab (LL) and a pig Living Lab. The participating stakeholders in the two Living Labs were identified based on stakeholder's interviews conducted during the stakeholders' mapping.

Cattle Living Lab

In the project proposal, we had indicated that the ROADMAP Case Study on cattle would be focused on organic dairy cattle, and more specifically take the starting point in one particular dairy company which had had a focus on phasing out antibiotics since 2003. The ROADMAP project team at Aarhus University thought that this would be an interesting example of a target-directed effort among producers toward prudent AMU. However, during the first gathering of the cattle Living Lab, it became clear already at the first meeting in October 2020, that many stakeholders did not support the idea of focusing on minimising AMU in organic dairy herds, but rather broadening it out to all dairy herds, including the conventional. If ROADMAP aimed at having an impact on AMU, this focus would be much more relevant. In the conventional herds, farmers had access to AM for first-time treatments, and the AMU was generally higher. It was also mentioned that AMU in calves was increasing, and therefore, a group of stakeholder representatives from both dairy and calf farming were invited.

There were 11 participating stakeholders or stakeholders' organisations involved in the cattle LL:

- One practising cattle veterinarian experienced with interdisciplinary advisory service
- One practising cattle veterinarian involved in stable school development for AMU reduction
- One practising cattle veterinarian with a speciality in calf herds and calf diseases
- One representative for the Danish Society of Veterinarians, Section on Production Animal
- One representative for the farming sector's own advisory body SEGES
- Two representatives from a calf advisory and equipment company called Calvex
- One representative from an abattoir (the second biggest in Denmark) 'Himmerlandskød'
- One representative from a large dairy company, ARLA Foods Ltd.
- One lecturer at Copenhagen University in cattle management and cattle diseases
- One PhD student from Copenhagen University focused on AMU reduction in cattle farming

The LL-stakeholders were encouraged to identify additional stakeholders to the LL, but they decided in October 2020 as well as in June 2021 to keep this group as a core group.

Six meetings of the cattle LL took place between October 2020 and May 2022 (four in situ and two online). Three thematic group Action Labs were organised in March 2021, one on preparing changes in practice, one on education and learning, and one on legislation and marketing.

Pig Living lab

For the **pig Living Lab**, it became clear that many pointed out that a major lock-in achieving a lower AMU in Danish pig production was the difficulty to obtain a premium price for meat that was produced without using antibiotics (Pure Pork label). Stakeholders from the whole production chain – from farm to supermarket - were invited.

The pig Living Lab had 11 participants initially but only nine by June 2022 :

- A farmer producing "Pure Pork"/ OUA
- A farmer producing conventional pigs with a low AMU (still participant but by October 2021, no longer pig farmer)
- Two practising pig veterinarians from different companies
- Two farming consultants from different companies
- Chief Consultant, veterinary research and Development, Seges, Danish Agriculture & Food Council [joined between 1st and 2nd LL as a stand-in for the person from Seges, that we originally invited to join, who was too busy. The ROADMAP team was not involved in this change]. From October 2021 the representative from Seges was withdrawn by Seges directory board. This was done due to a restructuring in Seges/Danish Agriculture & Food Council, which in the future would be divided into an advisory section and a political section. The management team suggested that the political section would be represented in the LL instead of the representative from the advisory section. However, the AU facilitator team referred to having a representative from the advisory section involved rather than a political representative because the work in the LL was more targeted toward finding solutions and identifying potential innovations concerning the AMU structures at the herd and sector level, which required professional knowledge on AMU in pig production as well as social structures around the chain. Therefore, the Seges-representative was not replaced by a politically working representative from the Danish Agricultural & Food Council
- Chief Consultant, Market (export) and Nutrition, Danish Agriculture & Food Council (In January 2022 she could not participate any longer due to workload and no substitute was possible)
- Professor in consumer behaviour, Aarhus University
- Consultant, Danish Crown
- Head of CSR Coop (supermarket chain)

Five meetings of the pig LL took place between November 2020 and May 2022 (three in situ and two online). There were also two action lab meetings that were organised in March 2021, and a roundtable in April 2022 (on AMU-AMR-Debate on what do we agree and not agree on).

Additionally, a joint webinar on AMR resistance was organised in January 2021 and a joint meeting for cattle and pig LL´s and invited stakeholders in October 2021.

4.1 Initial assessment

Danish veterinary antimicrobial use (AMU) context

In Denmark, AMU in animal farming is primarily driven by pig production. Thus, 75% of antibiotic active compounds are used for pigs – even though their live biomass only constitutes 43% of the total live biomass of Danish livestock. According to Danmap, a yearly report on AMU in animals and humans in Denmark, the frequency with which pigs are treated with antibiotics has decreased by 30% over the past decade (from 3.3% in 2010 to 2.3% in 2019 of all Danish pigs receiving some sort of AM treatment on a given day). Compared to other countries with similar industrialized pig production, the usage of antibiotics in Denmark is low. AMU is strictly monitored by the national authorities via the database Vetstat (which is publicly accessible). All use of antibiotics for animals is through a veterinary receipt. Veterinarians do not earn money from the antibiotics prescribed. If farmers use antibiotics in amounts above-set thresholds (Yellow card limits which are gradually decreased over the years) they can be underlain certain restrictions.

AMU in pig production

There are three different main production types for pigs in Denmark: conventional indoor, organic and conventional free-range. They are under different regulations concerning stocking density, outdoor access (none in conventional indoor herds), feeding (eg. roughage required in organic and conventional free-range production) and antibiotic use (most restrictive rules in organic herds).

We investigated the antibiotic usage within the three production systems using data from the Vetstat database from 2015 to 2020. Within the conventional indoor systems, some niche production systems like ”Pure Pork”/ OUA label production could have different levels of AMU, however, it was not possible to obtain data from these systems. The herd sizes of the three different production systems, that we were able to get data from, were systematically different, where the average organic herd was around 170 sows, the conventional free-range herds around 330 sows and the conventional herds around 700 sows. AMU in the conventional herds was substantially larger than in the organic herds, especially for weaners, where it was 8-10 times larger. For both conventional, organic and conventional free-range production systems there was a large variation between herds within the production systems and especially for free-range and organic herds, there was a large proportion with low or no AMU. For the conventional and free-range conventional herds, AMU was primarily associated with the weaners and the gastrointestinal organ system, an indication that the majority of treatments in these herds were for post-weaning diarrhoea. In organic herds, the proportion used for diarrhoea in weaners was not as markedly different compared to the other indications for use, however, still the most common reason to treat.

AMU in dairy herds

The Danish dairy sector has had an increasing focus over the past decades on animal health and welfare, as well as the way of using antibiotics. Antibiotic treatments could only be done as individual animal treatments by a practising veterinarian until 1995, when a new regulation made it possible for dairy farmers to do second-time-treatments themselves, given that the vet had diagnosed and treated the first time, and given that the farmers entered a so-called animal health advisory service agreements, where monthly advisory visits were part of it. Organic dairy farmers could not get antibiotics

for dairy cows, also not for second-time treatments, which also left them out of the animal health advisory service arrangement. Since 2010, a new regulation made it possible for dairy farmers to also do first-time treatments in their herds, given that they have a more intense animal health advisory service agreement, and that depending on the herd size, the veterinarian comes weekly or biweekly to inspect the herd, give advice and follow-up on the treatments. In this arrangement, a strict 'diagnostic and treatment plan' is made for every disease expected or experienced in the herd, e.g. different types of mastitis, calf diseases, metritis, lameness etc.

AMU in dairy farming especially regarding mastitis treatments of dairy cows, has generally been reduced, and the AMU in calves has increased over the past few years, which made the Living Lab stakeholders emphasise this focus. The Living Lab comprises both organic and conventional dairy cows and calves, the case study has had a focus on analysing parallel lines and initiatives throughout the dairy sector, and combine calf and cow focus to provide relevant new insights. Furthermore, calf fattening herds received calves both from organic and conventional herds, and generally, the health and welfare of calves are not prioritized as much as for dairy cows, which made the LL conclude that this focus was probably the most relevant.

4.2 Problem(s) addressed by the initiative

Pig LL

Regarding diagnosis of the situation, a general central issue was already predefined by taking in information from the stakeholders' mapping interviews: "It is difficult to sell pork produced without the use of antibiotics (Pure Pork) at a higher price to cover the additional costs". In phone calls with all participants before the 1st pig living lab, all agreed on this general central issue.

To build the vision of the future, we followed the ex-ante assessment steps and spent one hour of the first LL talking about individual and common goals for the LL. The participants were asked to write their answer (on cardboard petals) to: "What do you want to get out of your participation in the LL?" The petals were collected to build a flower (Figure 4.1).

The flower was discussed and from the discussion, a common goal was formulated and it was agreed to be the starting point for future dialogue: "*By optimizing the use in the stables and thereby reduce the average antibiotic consumption being able to communicate accurately to communities, consumers and customers and thus ensure sales.*" The phrase must be understood in the context that consumers are interested in animal welfare.

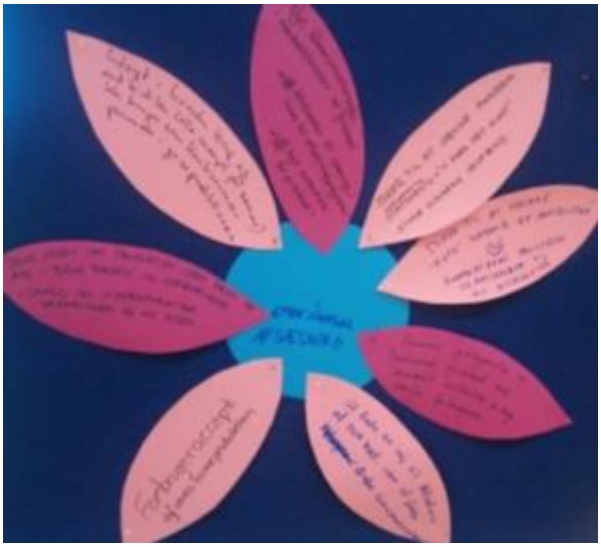

Figure 4.1: Vision of the future for the pig LL in Denmark

During the first LL, a problem tree (Figure 4.3) was built. From the problem-tree grew six main branches and three of them were explored in detail: 1) low demand for meat produced without AM; 2) AMU/AMR issue is not often in the public debate; 3) reluctance to change AMU practices in animal production. Although the three branches started differently they all ended out saying something like: "lack of knowledge and awareness" and "the consumers don't perceive the link between AMU in animal production and AMR in public health". So from the discussion, during the making of the problem tree, we ended up concluding that focusing on a label would not be constructive enough. The participants agreed that they would rather focus on the whole Danish pig production as such. We as organisers found that the most important issue was to find out *if* there is a link between AMU in animal production and AMR in public health. This decision did lead us to hire experts for the joint webinar on AB resistance for pig and cattle LL´s.

Cattle LL

Regdarding the diagnosis of the situation, it was already clear from the stakeholders' interviews that the coming LL should focus not only on organic agriculture, but include conventional agriculture, and include both dairy cows and calves from dairy herds. So, it was clear from the start that there was a common problem across cows and calves, although they are sometimes seen as two distinct sectors.

For the vision of the future, two different 'horizons' for the future were used (Figure 4.2): the first one a nearby future (after the first two years of Living Lab), and the second a more distant future. Each representative wrote their 'vision' and based on this, we tried to suggest a formulation for a common vision. This proved to be more difficult for the first vision, whereas the second and long-term vision seemed more clear. The first 2-year vision "*Having a common understanding and tools for change of practice*" was mainly suggested by the organisers and confirmed by participants, but with several additional suggestions. The long-term vision was generally focused on AMU reduction with no negative side effects regarding animal welfare.

Figure 4.2: The two 'vision flowers' of the Danish Cattle LL

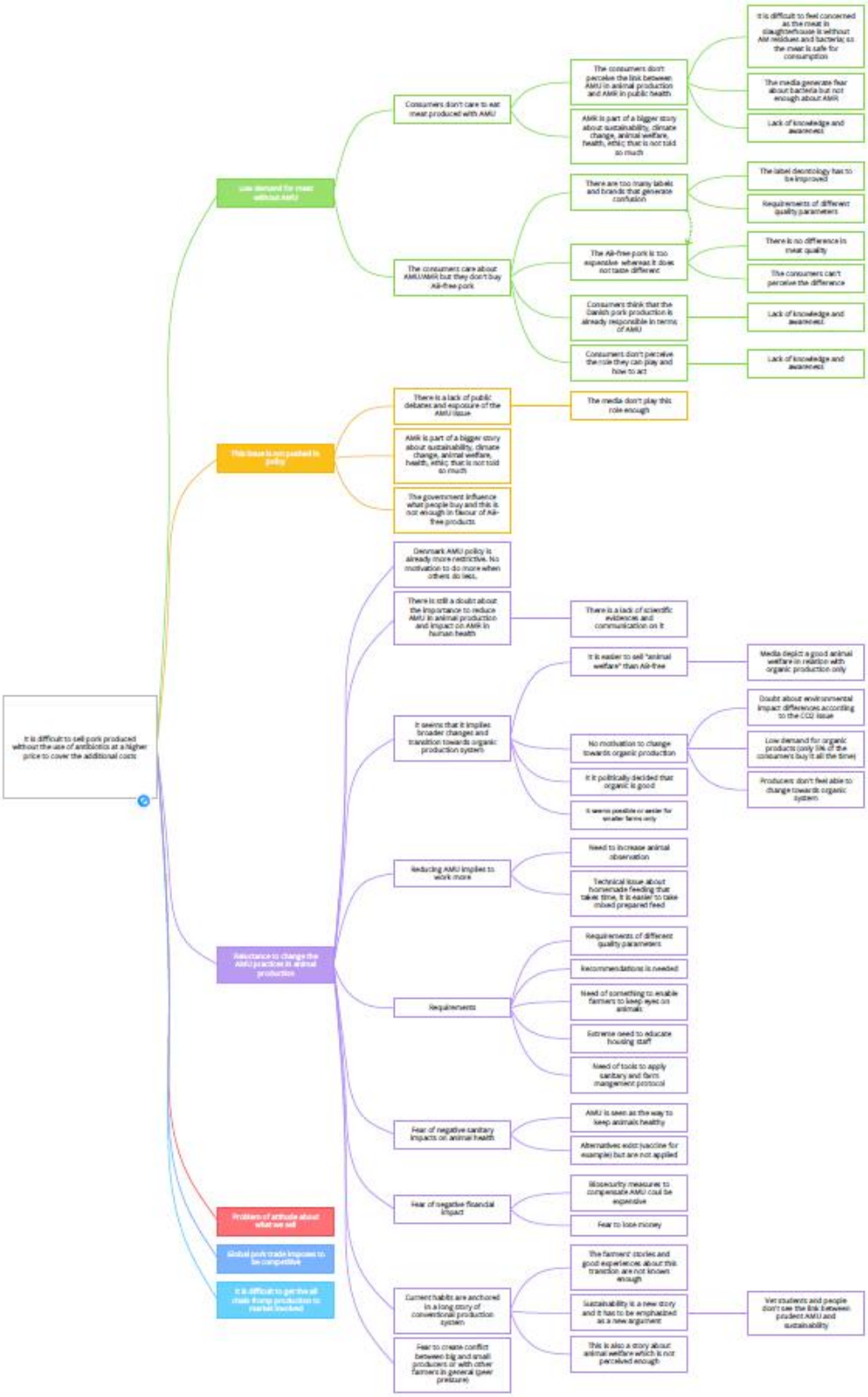

Figure 4.3: Problem tree for the Danish pig LL

Figure 4.4: Problem tree for the Danish cattle LL

The cattle LL identified many different and complex issues summarized in Figure 4.4. This formed a background for three thematic groups, which all discussed the problems which they targeted in particular, at their first meeting.

We identified some root causes for the targeted problems, such as economic structures, pricing and incentives (e.g. in terms of subsidies), and the disproportionate interest in milk vs. calves from dairy farming. This seems to be a problem across countries in Europe, which led to a joint workshop in June 2021 across the cattle LLs from United Kingdom, Switzerland, Belgium and Denmark, and the Danish LL has had an exchange about that in a LL core group meeting.

4.3 Narrative and impact pathway of the initiative

The precondition to performing the LL´s was that the participants agreed that change was needed toward a prudent AMU because it would help reduce the global threat of AMR.

However, this was questioned, especially in the pig LL. Generally, the participants in the Living Lab felt that we in Denmark perform well concerning AMU in animals and therefore, basically, do not need major change, especially not if the connection between AMU in farm animals and AMR in humans was undocumented. Since LL is a user-centred approach, we agreed in the LL that we needed to explore this question: 'What is the connection between AMR (globally) and AMU in Danish animal farming?' to have robust arguments and directions for our efforts to change AMU in Danish pig farming.

Therefore, we organised a seminar – online due to Covid-19 – where three experts taught us about the relationship between AMU and AMR, and the concerns and questions were partly answered. The seminar enlightened all of us but did not convince us fully that we needed to do more in the Danish pig sector in general. In addition to this, we organised another common event for the cattle and pig LL and several guests, identified by the LL stakeholders. This event was a presentation by an expert on AMR in the environment, followed by Q&A and a debate. On the same day, a workshop was held on commonly identified levers and barriers to change AMU in the afternoon.

Both Living Labs agreed that there was a big difference between herds – both pig herds, dairy herds and calf herds – regarding AMU and that it was relevant to explore and focus on how to reduce AMU in the herds with current high use.

In the **cattle LL**, there were clear ambitions among stakeholders to reduce AMU, especially for the calf sector. It was found relevant to continue efforts, which focused on education (agricultural colleges, farm workers, farmer groups), changes in practice, and ensuring an appropriate legal framework for veterinary interventions in dairy and calf herds.

In the **pig LL**, the stakeholders decided to create an App, which could help immediate decision-making in disease situations, and give a quick overview of the herd. This App should also be a tool for better communication and sharing of experiences in the herds. A group of stakeholders started working on this app, which proved to be interesting but also more complicated than originally foreseen.

The other action of the pig LL was a Round Table aiming at "creating consensus on relevant factors regarding AMU in Danish pig production and at the same time explore disagreements". For preparation, several questions were formulated and grouped, and from there experts to invite for the meeting were suggested. Five topics were in focus: 1) AMU and AMR; 2) Consumers citizens and antibiotics; 3) AMU and alternatives; 4) Breeding for robustness, the way forward?; 5) Are changes in AMU needed in the Danish pig production and if so who should take the responsibility?

The debate for the first four topics was arranged as a Samoan circle process: four speakers were invited to initiate the debate with a two-minute talk on the specific topic sitting on a "speakers chair". The rule was that you were only allowed to speak if you sit on a speakers chair. The fifth topic was a debate for all participants in the same circle. The debate over the whole day was engaged and respectful. At the end of the day, it was still not clear if changes in the Danish pig production or its AMU were needed.

To further explore the reasons behind very different levels of AMU between herds, we organised a presentation on AMU and health in organic pig production given by a researcher (one of the LL facilitators) and a presentation on AMU and management in organic pig production given by a veterinarian who worked in a large organic herd. We had a fruitful debate and the conclusion was that some of the experiences from organic farming (e.g. change of sow-hybrid to one giving birth to fewer but heavier piglets) was inspiring.

The impact pathway of the initiative is presented in Figure 4.5 and detailed hereafter.

Regarding **inputs**, facilitation needs an incredibly large amount of time. It involves not only LL-meetings, but also facilitating exchange between busy practitioners and stakeholders between meetings. External stakeholders and experts were involved where and when relevant and needed in order to understand the issues and the current state of art. All stakeholders (researchers, farmers, veterinarians, etc) invested time to participate, to prepare, to communicate and to reach mutual understanding on the issues. Meeting facilities were an essential component for live meetings and were arranged to favour participation (for e.g.participants were not allowed computers and were arranged in a circle). Depending on which actions the Living Lab or the Action Lab decided on (e.g. education material, film-making, development of app, and other initiatives), specific equipment and material was also needed. Finally, funding from ROADMAP was indispensable to organise activities. Additional funding from Seges and Danish Agriculture & Food Council is needed to develop the app but has not been given yet.

Until now **outputs** of both pig and cattle LLs have been LL-meetings, meetings with invited stakeholders, seminars with invited experts, and also physical outputs, some of which will be tested in practice, (e.g. calculations in calf herds, education material, videos, specifications for a phone app, etc). One of the initiatives in the cattle LL to have set up an exhibition at the Danish national Cattle Conference (a two-day event) received much attention and positive feed-back. Likewise, the development of 'discussion cards for the lunch table' with questions about AMU in daily practice as well as on an overall sector level has received interest and positive attention. The following other outputs are expected:

<u>For the pig LL:</u>

- A workshop on animal welfare and low AMU
- Joint meeting and co-learning event with other ROADMAP LL´s in Belgium
- Contact different educations to explore which type of teaching material could be useful; this could potentially be done in collaboration with some of the initiatives from the cattle LL
- Exhibition at the yearly Danish pig congress
- Phone app with three modules and the training on how to use it

<u>For the cattle LL:</u>

- Education material for agricultural colleges and veterinary education
- Follow farmer groups and farmer employee groups on their discussion on AMU
- Work on how the Living Lab can potentially become a lasting structure in the sector
- Organise a co-learning event in Denmark between Living Labs from the United Kingdom, Switzerland, Belgium, France and Denmark
- Focus on identified options for improving the structures around calf farming, including transport, housing, education and practices on identifying and handling disease
- Influence the way in which the legislation for veterinary interventions, advisory service and disease handling is implemented in practice

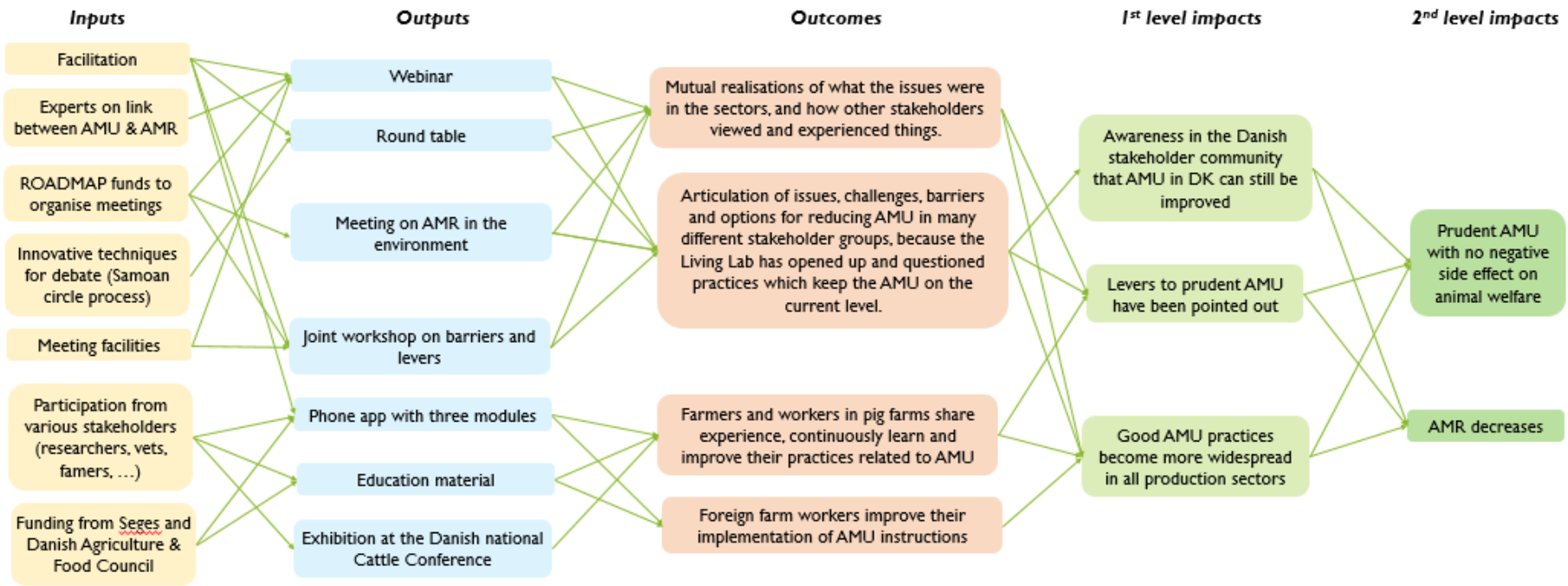

Figure 4.5: Impact pathway for the pig and cattle Living Labs in Denmark

The above mentioned inputs and outputs have contributed to the following **outcomes**:

- Important mutual realisations of what the issues were in the sectors, and how other stakeholders viewed and experienced things. This has partly been acknowledged in the evaluations of the meetings. However, it has also been concluded that it might not be obvious instantly, but took time to realise and especially to reach common agreements on what the issues and challenges were and are.
- Articulation of issues, challenges, barriers and options for reducing AMU in many different stakeholder groups, because the Living Lab has opened up and questioned practices which keep the AMU on the current level. For example, in the pig LL, everybody seemed to realise that AMU is more or less a result of how the Danish pig production sector is structured. Another important common realisation is how differently AMU in pig production could be viewed from different angles.

It is expected that current and future outputs including education material, exhibitions at sector based-conferences and the pig phone app will contribute to farmers and farm workers learning about good practices, implementing them and sharing their experience. Efforts will be made so that foreign farm workers (for which the language barrier means that they sometimes misadminister AM treatments) also improve their practices.

In terms of **impacts**, the short-term (two year) vision of the cattle Living Lab "Having a common understanding and tools for change of practice" has been reached. The long-term vision of the cattle Living Lab was generally focused on AMU reduction with no negative side effects regarding animal welfare. The desired impact for the pig Living Lab for the ROADMAP period was also to optimise and reduce the average antibiotic consumption, with a focus on being able to communicate accurately to communities, consumers and customers and thus ensuring sales. On that matter, an important barrier to significant change in AMU was identified as the pig sector's focus on export, and it was realised that prospects of reducing AMU would be different if the sector focused on the national market.

The above outputs and outcomes are targeted toward improving the common understanding of the sectors and the issues around health and welfare promotion, as well as social and societal structures that are levers or barriers for prudent or reduced AMU, and education as well as communication.

4.4 Impact indicators for the initiative

Especially three categories of impacts are in focus, and we plan to identify indicators related to these three categories of impacts:

1) **Social innovations** in terms of material and process guidelines to talk about AMU in herds, farmer groups, and relevant education.

2) **Ripple effect of dialogues and common insights coming from the Living Labs**

Right from the start of the cattle- and pig LL´s, the LL participants told their colleagues in the stakeholder organisations, what was going on in the living labs. This resulted in us being contacted by new stakeholders who wanted to be part of the LL. This and other indications of 'rings in the water' from the Living Labs have been experienced, such as asking the cattle Living Lab to help co-reflecting on antibiotic guidelines from companies, and suggesting a process to let the ROADMAP LL stay in action beyond the project period.

3) **Open eyes and ears – the first steps to a change**
The multistakeholder approach and process with sector-specific as well as exchange between sectors have been eye-opening for many stakeholders. These insights, which seem to have influence on the debates in different fora within the sectors.

The Danish Living Labs have not developed indicators yet, but still plan to have a year more to work on the outputs. It has become very clear that actual changes in AMU requires time and negotiation, and therefore indicators are directed towards impact and changes on the articulation and structures around AMU. During the last year of ROADMAP, we will elaborate on how to measure the impact of material on AMU-related practices, and social innovations and processes which come out of the project, including the ripple effects and eye-openers.

5 ROADMAP initiative in France

Course of the work

WP6 activities in France involved nine participant representing different French institutions that can play a role in the innovation process and in the construction of strategies towards improved AMU. There were two representatives of the pig and poultry technical institutes (IFIP, ITAVI) which carry out research and development activities to support the sectors; two representatives of the pig and poultry inter-branch organizations (INAPORC, ANVOL) which represent all the links of the supply chain and defend their interests; two representatives of the pig and poultry commissions of the National Society of Veterinary Technical Groups (SNGTV); one representative of the National Union of Veterinary Consultants (SNVECO) which represent the veterinary practitioners and advisors working in livestock and defend their interests; one representative of the National Order of Veterinarians and one representative of the General Directorate of Food of the Ministry of Agriculture and Food (DGAL) which were respectively developing the Calypso project (which aims to collect antibiotic prescription data on a digital platform) and the third national Ecoantibio plan.

Nine semi-structured interviews were held in April-May 2021 and five participatory workshops were organised: one online (on the 25th of May 2021), three concomitantly on site and online (on the 10th of November 2021 and on the 10th of January and 3rd of February 2022), and one online (on the 18th of May 2022). All interviews and meetings were transcribed. Outputs of each meeting were written in a report and sent by email to the participants for subsequent correction/validation.

5.1 Initial assessment

Awareness about the problem of AMR gained momentum in France in the 2000s with the first national campaigns to reduce AMU in humans ("Antibiotics are not automatic"). In the veterinary sector, the EU-impulsed ban on the use of antibiotics as growth promoters in animal feed entered into effect on the 1st of January 2006 and was followed by a mobilization of the veterinary public authorities to try to change the practices of prescribing and using antibiotics, in partnership with the different actors concerned, especially veterinarians and farmers. Efforts accelerated at the end of the decade when France participated in the ESVAC (European Surveillance of Veterinary Antimicrobial Consumption) project, which was launched in September 2009 by the EMA (European Medicines Agency) with the objective of collecting harmonized antibiotic sales data for all EU countries. Furthermore, it launched an unprecedented two-year consultation process, bringing together several ministries (agriculture, health, environment, research, economy), the world of research-education, veterinary drug manufacturing and distribution companies, veterinary drug stakeholders (Veterinary Order, Pharmaceutical Order, veterinary professional organizations), risk assessment agencies, veterinary laboratories, agricultural technical institutes, health organizations and veterinarians' and farmers' unions, and finally, agricultural inter-professional organizations for livestock.

This mobilization led to the creation of the first Ecoantibio plan, which was launched on the 18th of November 2011 by the Ministry of Agriculture. Its motto was "decrease is possible" and it had two objectives: to reduce the use of antibiotics in veterinary medicine by 25% in five years and to preserve the therapeutic arsenal in a sustainable manner. The significant involvement of all stakeholders enabled this first plan to go beyond this objectives and achieve a 36.5% decrease in animal exposure to antibiotics over the 2012-2016 period. This first plan was characterized by a focus on legislative and regulatory provisions: three articles of the Law of the Future for Agriculture, Food and Forestry (LAAAF) of the 13th of October 2014, two interministerial orders (22nd of July 2015 and 18th of March 2016) and a decree of the 16th of March 2016 contributed to profoundly modify the use of antibiotics in veterinary medicine. New ethical duties regarding the responsible use of antibiotics were enacted; it was forbidden to collect or grant rebates or discounts when purchasing medicines containing antibiotic substances; finally, the prescription and dispensing of critically important antibiotics (fluoroquinolones and 3rd and 4th generation cephalosporins) were more strictly supervised, with a goal of reducing their use by 25% in three years (between 2014 and 2016).

The launch of the Ecoantibio2 plan for the period 2017-2021 aimed to continue the momentum, now focusing on the continuation of efforts based on incentive rather than on legislative measures. This plan nevertheless included the obligation to declare all sales of antibiotics and objectives to reduce the exposure to colistin in the cattle, pig and poultry sectors by 50% in 5 years (taking the average ALEA for 2014-2015 as a reference).

As of 2020 and in comparison with 2011 (year when the first Ecoantibio plan was launched), animal exposure to antibiotics decreased overall by 45.4% in France, with large disparities between species: 22.5% for cattle, 55.5% for pigs, 64.4% for poultry, 39.9% for rabbits and 11.8% for cats and dogs (ANSES, 2021). Progress has therefore been substantial, especially compared to human medicine where the reduction in antibiotic use was only 11.4% between 2000 and 2015 (ANSM, 2017), and this was considered as a source of pride for veterinarians.

The reduction in AMU has been particularly important in the pig and poultry sectors and it seems that nowadays, a plateau has been reached below which it will be difficult to go further. Our group of participants agreed that further improvement of AMU in these two sectors was possible but that this improvement should not solely focus on quantitative reduction of AMU but rather on qualitative improvement. Questions were indeed raised about a possible deterioration of animal health and well-being if additional quantative AMU reduction objectives were set.

5.2 Problems identified and addressed by the initiative

Based on the previous diagnostic of the situation, our participants established what their desired vision of the future was in terms of AMU in the poultry and pork sectors in France. They want that by 2031, the proper use of antibiotics is a practice that focuses on "better" and not just "less", applied in all farms and accepted by those involved in AMU (veterinarians, farmers, production organizations, pharmaceutical industries, etc.) and by those involved in the use of animal products (slaughterhouses, distribution, restaurants, consumers, etc.). This good practice, monitored by appropriate indicators, should make it possible to preserve the therapeutic arsenal while guaranteeing both animal health and well-being, and the sustainability of these sectors and of the veterinary network in the country.

Among the impacts they would like to contribute to, the long-term impacts include improved AMU and decreased AMR, better animal health and welfare, and improved resilience of animal farming (in terms of public image, economic sustainability, attraction for young people ready to embark on the job market…). Desired shorter-term impacts include:

- Good AMU is defined based on science
- Antibiotic users (vets, farmers, production organisations) and animal product users (consumers…) are sensitised about good AMU and how their choices and practices can influence AMU
- The link between AMU in animals and AMR (in humans, animals and the environment) is scientifically established
- Standardised appropriate indicators that combine monitoring of AMU, AMR, animal health and welfare are used
- The territorial network of veterinarians is sufficient to guarantee better use of antibiotics and health surveillance and management
- Good AMU practices are economically rewarded and allow farmers to resist European competition

The participants identified the central issue preventing the vision of the future from happening as the fact that pork and poultry consumption choices do not systematically take into account the use of antibiotics by stakeholders (veterinarians, farmers, production organizations, etc.) who lack or heterogeneously use the means and indicators (levels of use, health, welfare, antibiotic resistance, etc.) that allow them to adapt their practices in terms of treatment choices and farm management.

When investigating further the big types of problems composing this central issue, the participants identified 4 main branches encompassing 48 problems, some of which were interconnected (Fig 5.1):

Consumption

There is a divergence between the public's expectations (less intensive farming, organic products, quality products, animals raised at least partly in open air…) and its actual consumption choices (a low price is often the most important factor). This is generally attributed to **budget** issues: an insufficient purchasing power and the choice of reducing food budgets, either voluntarily or involuntarily.
Furthermore, a significant number of pork and poultry consumers do not prioritize "antibiotic use" as a consumer choice criterion. This is likely due to **communication** issues: the livestock sector has not communicated enough about the efforts it has made to decrease AMU in France over the last decade; labeling practices on "antibiotic-free" approaches are heterogeneous and there is a lack of information on the differences in practices between countries; and consumers may confuse the use of antibiotics to treat animals with the presence of antibiotic residues in animal products.

Competitiveness

There is heterogeneity in the application and monitoring of AMU indicators at the European level. It is feared that French standards, which are or would become stricter than those of their European competitors, would degrade the competitiveness of the French poultry and pork sectors. The competitiveness of French farms is all the more an important parameter that investment capacities (to improve buildings, develop preventive approaches, etc) are currently limited because of previous investments to keep up with European norms and in a context of very low prices paid to producers.

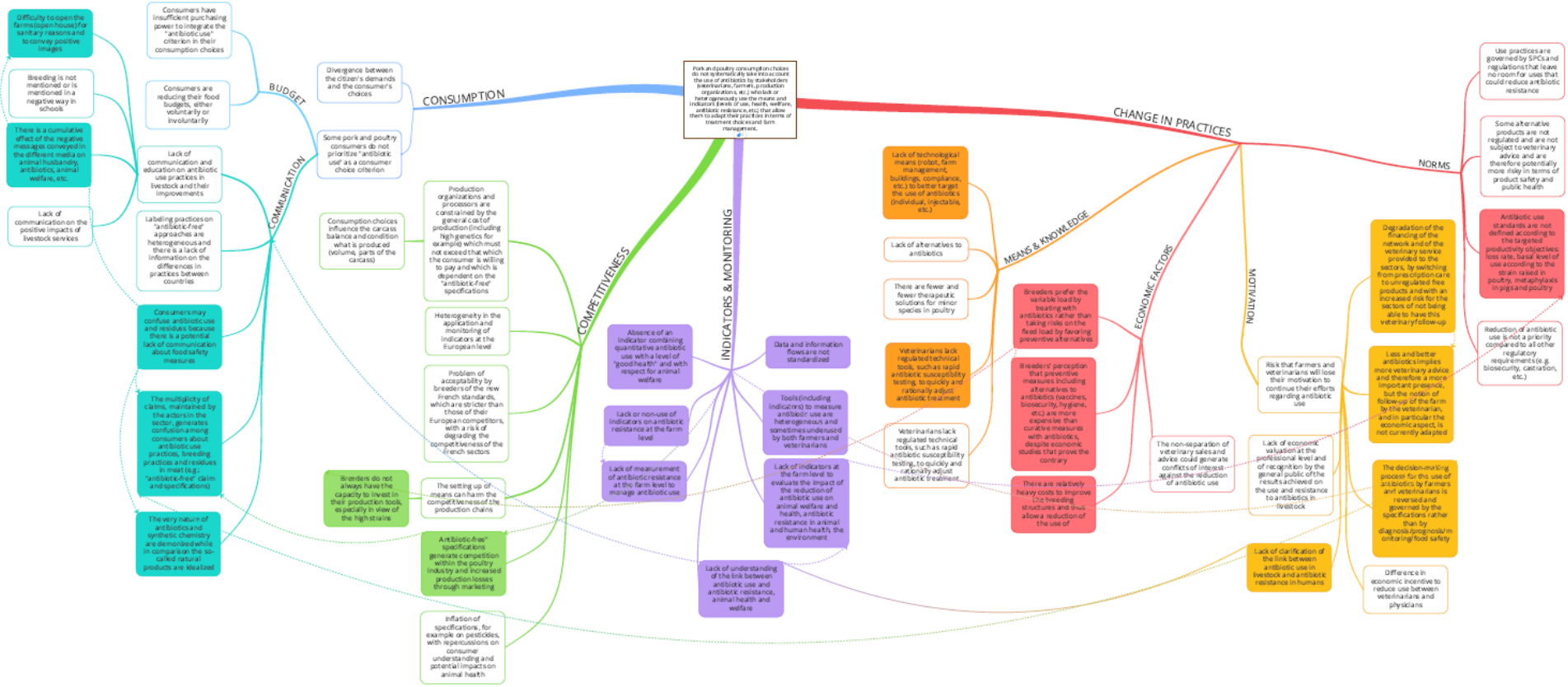

Figure 5.1: Problem tree listing all problems identified as preventing the desired vision of the future in terms of AMU, animal health and welfare and economic viability in the pig and poultry sectors in France

Changes in practice

Participants identified a **lack of knowledge and means** that prevented changes of practices towards improved AMU: obstacles to changes specific to each type of stakeholders are not identified; there is a lack of alternatives to antibiotics; there are fewer therapeutic solutions for minor poultry species (quails, Guinea fowls…); veterinarians do not have regulated technical tools (such as rapid antibiotic susceptiblity testing) to quickly and rationally adjust antibiotic treatment; and there is also a lack of technological tools (such as robots) to better target and administer antibiotics.

Economic factors also played a role since farmers tend to prefer variable expenses (such as AM treatment given only when animals are sick) rather then fixed expenses (such as preventive alternatives, for example vaccines that are systematically administered to all animals). Farmers indeed believe that preventive measures (including vaccines but also biosecurity, hygiene, etc) are more expensive than curative measures despite economic studies proving the opposite. It is nevertheless true that improving farming infrastructure implies heavy costs. Regarding veterinarians working in rural areas and/or exercising a predominant activity on livestock, it was observed that the decrease in AM sales and the ban on rebates and discounts by AM-producing pharmaceutical companies led to a consequent loss of turnover and thus economic weakening for practitioners. It has indeed been difficult for veterinarians to shift to a new business model based on advice rather than drug sales, in a context where farmers have been used for decades to benefit from free advice from veterinarians. These latter may therefore be reluctant to further decrease AMU, in particular if this means it won't be profitable to work in rural areas/on livestock species anymore. The decrease in the number of livestock veterinarians could fragilize the national veterinary health surveillance network, which also intervenes in case of major outbreaks (foot and mouth disease, tuberculosis, avian influenza, etc).

There is also a risk that farmers and veterinarians will **lose their motivation** to continue their efforts regarding AMU: given the decrease in ALEA (animal-level exposure to antibiotics) that has already been achieved, some argue that the link between AMU in livestock and AMR in humans needs to be scientifically demonstrated. Furthermore, specifications for all production aspects in farms belonging to highly integrated firms tend to reverse the decision-making process for AMU which is based on terms of references rather than on more local context-specific factors.

Indicators and monitoring

Different initiatives have encouraged the design of a multitude of indicators, which are sometimes mobilized in an inappropriate or non-optimal manner in the absence of a consensus on their use. In the pig and poultry sectors, the ALEA indicator, defined by ANSES, is commonly used; but there are also other descriptive usage systems and other private systems with their own indicators and methods of calculation and interpretation that respond to specific objectives and questions. Data and information flows are therefore not standardized.

The various initiatives have also influenced the emergence of different "antibiotic-free" labels and charters that include variable criteria, particularly on animal welfare aspects, and with their own AMU monitoring systems. These charters have the advantage of quantitatively reducing the use of antibiotics, but can sometimes be a constraint for farmers when they tend to avoid curative treatment (necessary to guarantee the health and well-being of animals) in order not to lose the economic bonus of "antibiotic-free" labels.

There is also a lack of indicators at the farm level to evaluate the impact of the reduction of antibiotic use on animal welfare and health, antibiotic resistance in animal and human health and the environment.

- ➔ Among all the factors identified by the participants to improve the way antibiotics are used, **the need for indicators at the farm level** to monitor the situation appeared to be crucial and a priority. This problem was furthermore selected for an intervention because the participants felt legitimate and in capacity to build strategies to address it.
- ➔ The second most important problem was identified as **economic issues** around farmers (their perception of the respective cost of AM treatment vs its alternatives, their capacity of investment and their competitivity on the European market) and veterinarians (their ability to move towards a business model based on advice).

5.3 Narrative and impact pathway of the initiative

Following the identification of problems, participants decided to set up an initiative that would contribute to address the following priority problem: "Lack or non-use of standardized means and results indicators that, when properly combined, allow for the adaptation of antibiotic use at the farm level with respect to the objectives in terms of animal health and welfare, antibiotic resistance in livestock production, competitiveness, and impact on public health and the environment".
The objective of the initiative will be to **build indicators that can be used to report in a simple and optimal way information about the health of animals, their well-being, the use of antibiotics and bacterial resistance to antibiotics**.

Inputs and outputs

In order to achieve this, an "**action lab**" will be set up that will gather representatives of the pig and poultry technical institutes (IFIP and ITAVI), the pig and poultry inter-branch organizations (INAPORC and ANVOL), pig and poultry farmers, the National Society of Veterinary Technical Groups (SNGTV), the National Chamber of Veterinary Surgeons and the National Union of Veterinary Consultants (SNVECO), researchers working on pig and poultry production as well as researchers working on animal welfare, and the Ministry of Agriculture and Food. Whenever needed, other actors may be included in the action lab such as specialists on AMR surveillance and AMU indicators (for example of the RESAPATH and AACTING networks), people with **experience from other AMU monitoring initiatives** or distributors of pig and poultry products.

Funding for the meetings of the action lab will be provided by the ROADMAP project during the first year, with complementary funding from the SANBA metaprogram (Animal Health and Welfare on Farm) of INRAE and from the Ecoantibio 3 plan of the Ministry of Agriculture and Food.

The **scientific literature** on AMU, AMR, health and welfare indicators will be reviewed and the needs of stakeholders in the field will be identified. AMU indicators will be refined, for example by molecule or family of antibiotics and by treatment modalities (age or weight at treatment). Health indicators will

also be improved to compensate for the facts that they are currently not collected in a systematic and homogeneous way and that they mainly pertain to animal productivity (prolificacy rate in pig farming, mortality rate in poultry farming) or to medical inputs. Such indicators on health disorders, which are more complicated to document routinely, will be designed through a consensus-seeking approach between scientists and practitioners (veterinarians, farmers, technical advisors). Welfare indicators will be adapted to take into account the rearing methods (confinement versus free-range). The action lab participants will also define the scale (animal, batch, flock, farm, etc.) and the frequency/period (continuous/real time versus at the end of the production cycle versus over a given period such as a trimester) for monitoring indicators.

The question of reference values, or thresholds or objectives to be reached, will also be addressed for the different indicators, as these values must take into account the diversity of situations encountered that lead to the prescription of antibiotics in pig and poultry farms, as well as variations in these values over time (kinetics as a function of animal growth and changes in the health of the animals in the farms).

In order to move from “less antibiotics” to “better AMU”, the latter must be objectively assessed using indicators that demonstrate that a minimum use of antibiotics is ensured, with this “optimal” use making it possible to limit the risk of the appearance and spread of bacterial resistance to antibiotics, while preserving the health and well-being of animals. This evolution is therefore based on combined results indicators, including parameters on animal health, animal welfare, antibiotic use and antibiotic resistance. It is important to link use and resistance in order to define the objectives not in terms of reduction of use, but in terms of reduction of resistance, the latter not being systematically linked to the level of antibiotic use. The new practices of prescription and uses of antibiotics must also be in the context of the economic viability of the different actors in the sector (farms, production organizations, etc.) and that of the actors in animal health, particularly the rural veterinary network.
The way in which these indicators can be combined will be discussed, as well as the synergies or antagonisms between indicators (e.g., between non-use of antibiotics and welfare), which will complicate the definition of “best use” and complicate decision-making in animal husbandry. Weighting of indicators may have to be considered. An example could be taken from what is practiced in human medicine, particularly in oncology, with the combined use of biomarkers of a heterogeneous nature (biological, clinical, imaging, histological, etc.), via a composite approach mobilizing several disciplines (clinicians, data scientists) within the framework of consensus conferences (Perrier 2022). This will lead to the production of **the combined indicators**, which will constitute one of the main outputs of the initiative (see Figure 5.2 for a graphical representation of all inputs, outputs, outcomes and impacts).

In order to avoid potential obstruction from production organisations that may be tempted to cling to their own indicators, they will be involved in the action lab right from the beginning. Their needs will be identified to assess how the combined indicators can help them for example for “steering” and decision-making purposes at the farm level, for visualizing “outlier farms”, for calculating returns on investments or for setting up national standards and labels that will be more clearly identified by consumers. In a context where animal welfare is a growing citizens’concern in France, **policy briefs** will be written by the action lab participants to convince all stakeholders of the pig and poultry production chain of the interest of developing labels that promote both good health and well-being practices (rather than just “AM-free” practices).

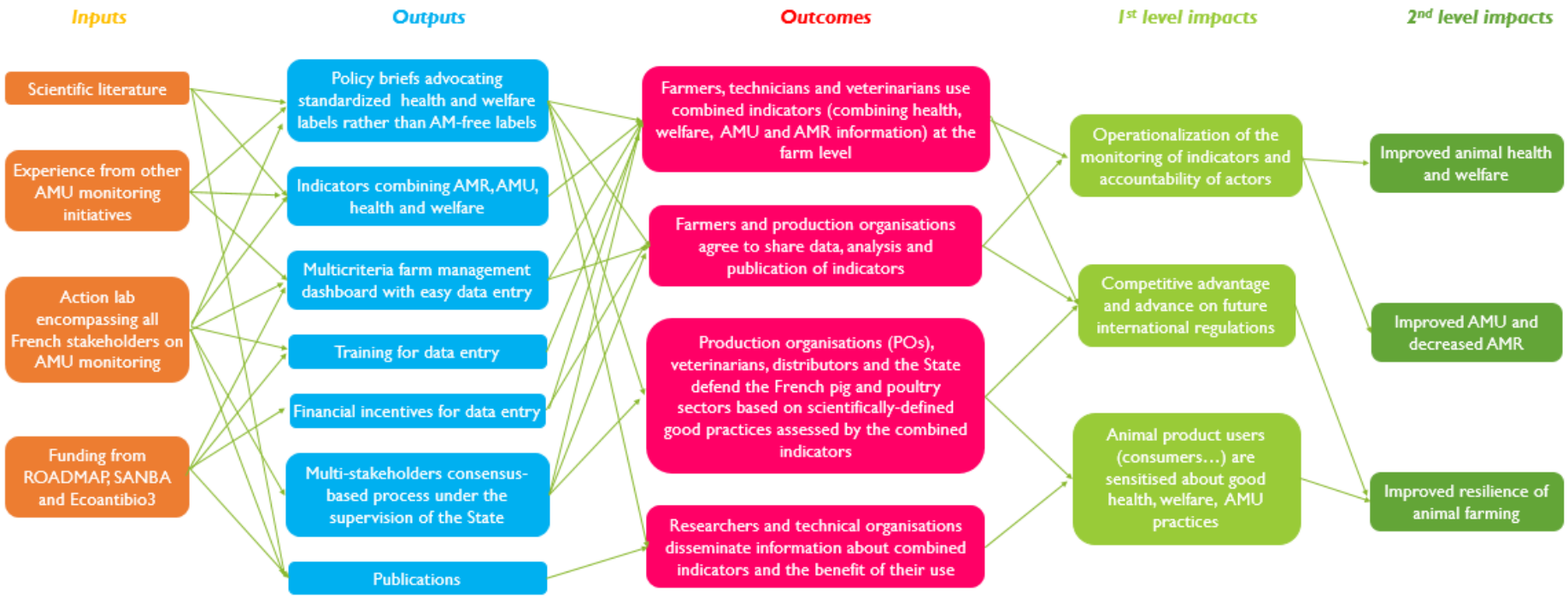

Figure 5.2: Impact pathway of the initiative designed to improve AMU indicators in the pig and poultry sectors in France

The government will also be solicited through the action lab (which will include one representative of the Ministry of Agriculture and Food involved in preparing the Ecoantibio3 plan, to be launched in 2023) and through policy briefs aimed at demonstrating the need for regulatory incentives towards standardized multicriteria (AMU, AMR, health, welfare) indicators at the national level.

The National Chamber of Veterinary Surgeons will also be closely associated to the development of the indicators given the proeminent role it holds in implementing European regulations on reporting AM sales and use data in France through the Calypso project. Synergies will therefore be ensured between all French initiatives towards AMU monitoring and improvement.

Embarking these national-level actors will contribute to help steer the process of defining indicators through potential issues linked to the competition among pig/poultry production groups and companies. The action lab indeed intents to develop a **multicriteria farm management dashboard** that will automatically calculate the combined indicators described before and will be easy to use for farmers.

Training manual and modules will be designed to facilitate appropriation of the dashboard as a tool aimed at adapting antibiotic prescriptions and monitoring the situation at different levels.

Questions are likely to be raised in terms of data ownership, access and transfer. They will be more easily addressed if treated under the supervision of the State, under a common objective of public health and animal health and welfare. **Regulatory obligations and/or financial incentives** for farmers to enter data in such tools may be needed from the government although it is not sure at this stage what the Ecoantibio3 plan and the next interministerial AMU roadmap plan will involve in terms of financial commitment.

Another output of the initiative will the **consensus-building process** between the various stakeholders involved in the action lab. Such participatory designs are indeed very valuable to improve knowledge-sharing and trust-building among actors with different constraints and priorities.

Finally, the initiative will produce **publications** based on the literature review and the design of the combined indicators.

Outcomes and impacts

The combined indicators designed jointly by all stakeholders of the action lab, with a strong emphasis on a users-need approach, **are expected to be largely used by farmers, veterinarians and technicians**. This change in the type of indicators used will be supported by the national-level endorsement, by the design of a user-friendly farm management dashboard tool, by appropriate training provided by the SNGTV and the production organisations (who are members of the action lab) and potentially by financial incentives (and/or regulatory obligations) from the Ecoantibio3 plan.

It is also expected that **farmers and production organisations will be prone to sharing and publishing data on their indicators** since the potential claims and labels will be standardised nation-wide and

associated with the previously-mentioned indicators. Whether information is shared only at the cooperative/production organisation level or at the public level, this will will facilitate comparison about health, AMU and welfare practices among farms, thus allowing targeted actions aimed at improving things in farms with poor indicators' values.

The scientifically-defined good practices, assessed by the combined indicators, will then spread more easily, **boosting the performance and reputation of the pig and poultry sector in France**. Labels (for example "French pork") developed based on the combined indicators would further help defend the interests of the French pig and poultry sectors in the competitive international market.

This standardisation of labels associated with **communication in the media and outreach of scientific publications** results towards the general public will help educate consumers who are currently quite confused by the profusion of AM-free claims (which vary largely among distributors) and tend to mistake AM use and presence of AM residues in animal products.

Overall, these outcomes will contribute to operationalize the monitoring of AMU (and health and welfare and AMR) indicators, to make pig and poultry actors more accountable, to increase the competitive advantage of the French pig and poultry sectors (potentially providing advance on future regulations that would be adopted at the European level), and to raise the awareness of consumers about good pig and poultry production practices.

In the long run, this initiative around the design of improved indicators will contribute to improve animal health and welfare, to improve AMU and decrease AMR and will strengthen the resilience of pig and poultry farming in France.

5.4 Impact indicators for the initiative

We did not have time to design impact indicators at this stage but they will be discussed during the meetings of the action lab.

6 ROADMAP initiative in Italy

Course of the work

WP6 activities in Italy involved several participants representing different Italian institutions that can play a role in the innovation process and in the construction of strategies towards improved AMU. Actions involved two workshops, one for the pig sector (15th July 2021) and one for the poultry sector (16th of December 2021), as well as thirteen semi-structured interviews with farmers and veterinarians.

The workshop on the pig sector focused on the updating of the guidelines on the use of antibiotics in pig farms elaborated by the public health services of the Emilia-Romagna region that had been adopted by the Ministry of Health as national guidelines. The regional major private and public stakeholders were invited, their representatives took part in the workshop, and contributed to the identification of the desired impacts. Based on the stakeholders' interventions, UNIBO identified and developed a list of relevant focus points submitted to stakeholders' validation.

The workshop on the poultry sector focused on a check-up of the national strategy implemented by the main Italian Association of the Poultry Industry (UnaItalia) by applying the FAO methodology of the AMR-Progressive Management Pathway (AMR-PMP). All the Italian major private and public stakeholders were invited, their representative took part in the workshop, and contributed to the identification of the impacts desired to improve further prudent AMU in Italian poultry farming. Based on the AMR-PMP report elaborated with the FAO, the main actions to be undertaken were identified and submitted to the stakeholders' validation.

Participants in the pig sector (total 29) workshop included:

- Regional Veterinary Services (3)
- Regional Agricultural Services (3)
- Ministry of Health - regional veterinary laboratories (1)
- Farmers' unions (2)
- Pharmaceutical industry (2)
- Retail sector (1)
- Interprofessional Organization (2)
- Supplements (2)
- Pig sector experts and consultants (2)
- Academia and research institutions - European project on AMR (11)

Participants in the poultry sector (total 39) workshop included:

- Ministry of Health - animal health (1)
- Ministry of Agriculture - research centre (1)
- Ministry of Agriculture - rural development (1)
- Ministry of Health - regional veterinary laboratories (4)
- Regional health services - animal health (3)
- Pharmaceutical industry (3)
- Poultry industry (8)

- Retail sector (1)
- Veterinarians' association (3)
- Consumer Association (1)
- International organization (5)
- Academia and research institutions - European project on AMR (8)

The workshops were attended both inhouse or online by the national poultry and pig sector stakeholders in Italy. All interviews and meetings were transcribed. Outputs of each meeting were written in a report and sent by email to the participants for subsequent correction/validation.

6.1 Initial assessment

The national One Health action plan on AMR (PNCAR) was adopted in November 2017 in Italy. The plan was prepared by a Working Group, set up in 2015. On 2017, by decree of the Director General of Health Prevention, the Working Group for the coordination and execution of PNCAR and the national law enforcement strategy was established. At the national level, a first plan for the responsible use of veterinary medicines and the fighting against antimicrobial resistance in poultry was issued in 2015: this was an initiative of the industry association (UnaItalia) supported by the Ministry of Health. This plan fixed a reduction target in the use of antibiotics for the Italian poultry farming of -40% (mg of active principles per kg of produced animal liveweight; reference year 2011) to be achieved by 2018. However, in 2016, the Italian poultry farms had already reduced the use of antibiotics by 50% with respect to the reference year. Taking into consideration this achievement and the issue of the PNCAR by the Ministry of Health, in 2017 UnaItalia published an updated version of its plan for the poultry sector.
Various prudent use guidelines (including species-specific ones) have been developed nationally. Overall, the private and public sector initiatives taken in recent years by the poultry industry and regional pilot projects involving pig farms (especially in the Emilia-Romagna region) led to considerable reductions in the use of antimicrobials. Several actions and elements can be pointed as responsible for such success: improved biosecurity, farm advisory services, focus on infection prevention and control, free diagnostic, and laboratory tests to farmers.

The Italian legislation establishes a system of routine checks on farm biosecurity, implemented by Local Health Services, for poultry and pigs in the framework of surveillance plans for specific infectious diseases (avian influenza and salmonellosis for poultry, swine vesicular disease and classical swine fever for pigs). In addition, pig farms to get and maintain the health declaration relating to Aujeszky's disease and Trichinellosis, are monitored to verify the structural and management requirements of biosecurity, as established by the sector regulation (National Biosecurity Plan for swine farms). The *Classyfarm* system provides a checklist focused on biosecurity (the Belgian UGhent tool for the pork sector), to carry out inspections on the farms involved in the system. Certification agencies offer protocols for labelling a product or a production system regarding specific standards; some of these standards refer to biosecurity, pest management, animal welfare and the overall quality system implemented. Only veterinarians should prescribe antimicrobials to animals; the prescription should be based on a diagnosis following clinical examination and laboratory tests.

Poultry farmers complying with the national plan of the Italian National Union of Meat and Eggs Agri-food Supply Chains (UnaItalia), are required to renounce any preventive treatment with antimicrobials both on farm and on the hatchery; consequently, antimicrobials are never administered to healthy animals, in absence of a specific etiological diagnosis. The vaccination program is one of the most preventive and effective measures in health management. In Italy, broilers are currently vaccinated for: Marek Disease, Infectious Bronchitis, Newcastle disease, Gumboro disease, infectious anemia, aviary encephalomyelitis, and viral arthritis and coccidiosis. Along with vaccination, other preventive measures are applied and have significantly contributed to the reduction of antimicrobial use namely improved biosecurity and the use of feed additives such as probiotics, prebiotics and organic acids which stimulate the immune system reinforcing the health status of animals and preventing the emergence of bacterial diseases.

Only pharmacies are allowed to sell veterinary medicines to farmers following a veterinary prescription. Veterinarians may not sell medicines to farmers. Medicated feeding stuffs are not supplied to farmers or holders of animals except on presentation of a prescription from a registered veterinarian. Medical sale agents can deliver free samples of medicinal products just to a veterinarian.
The use of the antimicrobial agents classified as Highest Priority Critically Important Antimicrobials (HPCIAs) is strongly discouraged in veterinary medicine, while administering to animals Veterinary Critically Important Antimicrobial Agents (VCIAs) is allowed with restrictions. Antimicrobial metaphylaxis should be prescribed only when there is a real need for treatment. In such cases, the veterinarian should justify and document the treatment based on clinical and laboratory findings on the development of a disease in a herd or flock. Prophylaxis should be reserved for exceptional case-specific indications, when the risk of bacterial infection is highly probable, and the consequences of its spread are serious.

Another action that affected the use of antimicrobial in the pig sector was the limitation in the use of colistin, especially with the introduction of the prohibition of its use associated with other antimicrobials. This fact strongly affected the use of colistin on weaned pigs, which today is almost zero. As consequence the use of therapeutic doses of ZnO increased, replacing colistin. The adoption of specific vaccination plans targeted for each farm gained consensus in 2020. The Experimental Zooprophylactic Institute (IZS) coordinates a project to produce vaccines targeted to specific pathogen strains of each farm. Other preventive strategies based on the improvement of the external biosecurity measures has been recently adopted due to the COVID-19 outbreak as well as the risk of diffusion of African swine fever that has already reached some EU countries. Together with the aforementioned strategies, the adoption of feeding strategy based on the low crude protein content and the use of feed additives like acidifiers, crystalline amino acids and probiotic, concours in increase the natural resistance of the pigs against pathogens.

An example of cooperation between competent veterinary authorities and trade associations on this aspect is represented by the national plans for the responsible use of veterinary drugs and for the fight against antimicrobial resistance. Supervised and issued by the General Directorate of Animal Health and Veterinary Drugs (DGSAF) in 2013 and 2015, they aim to apply all the tools necessary to develop and consolidate a preventive approach that reduces the use of antimicrobial therapies, defining targets for reducing their use in the implementation period.

The Italian poultry sector rapidly achieved the targets set by the National Plan – for example, in 2016, the overall reduction was already over 50 percent which is higher than the target to reach in 2018 (40 percent reduction of AMU), up to –92% in 2022. The results obtained in 2016, the evolution of the legislation, and the scaling up of the legislation induced a renewal of the National Plan in 2018, with more ambitious targets. Currently, given the results achieved in AMU reduction, poultry is no longer a main critical sector for intervention measures. AMU and AMR in the pig sector is now a major issue and therefore is the case study for which the impact pathway was built.

6.2 Problem(s) addressed by the initiative

The desired impacts identified by workshop participants were to have more competitive farm production, to have more efficient animal health interventions and to decrease AMU. The central problem was identified as a need to improve the AMU guidelines and strategies adopted respectively by the public health services and the private poultry sector. The problems identified as obstacles to reaching the desired impacts are described hereafter.

Pig case study

The pig workshop focused on a typically institutional tool (Guidelines published by the Regional Veterinary Services) and verified the need for its adaptation in function of the imminent change in European legislation regarding the use of veterinary drugs. Another context scenario is related to European agricultural policies: the EU has given an important role to the problem of AMR within its "farm to fork strategy" and has set a target to reduce the sale of antibiotics by at least 50% by 2030. The purpose of the workshop was therefore to identify, together with stakeholders, desirable adaptations and potential indicators to verify their effects, due to the evolution of the political and regulatory context at the European level. The proposals and wishes developed in this workshop were reviewed with integrative stakeholder interviews to identify the expected impacts (first and second level). This was defined in a document sent to validation by stakeholders. The main problems identified are described as follows and summarised in Figure 6.1:

Obstacles to the adoption of the Guidelines

Problems:

i. Long time frame: getting the farmer to adopt new practices takes time. It is a path of cultural evolution/education that the farmer may resist because he/she gets income from breeding and fears that a change may jeopardize his/her income;
ii. Lack of timely diagnostic responses: the shorter the response time, the more likely the Guidelines are to be enforced because the farmer has the laboratory outcome to refer to and is more likely to accept modification of a long-established (but no longer effective for developing AMR) therapy;
iii. Economic aspects: the farmer needs to be made to understand that adoption of the Guidelines does not generate additional costs, in fact it helps to reduce them. A supporting economic analysis is needed to provide evidence of this.

WHO or EMA classification?

Problem: The Regional Guidelines propose a division of antibiotics into I, II, and III choices based on their criticality, referring to the latest revision of the WHO classification of CIAs. The two classifications, WHO and EMA, do not overlap perfectly. The most notable difference is macrolides, which are not considered as choice III molecules, to be preserved more for the EMA, while in the WHO classification they are part of the CIAs. The choice of antibiotic to be administered is further complicated by field problems, such as the lack of registered molecules for some species (e.g., poultry and rabbits); in these cases the veterinarian finds himself by necessity using choice III molecules. Almost all EU countries adopt the EMA classification for macrolides, currently only Italy and Ireland use the stricter WHO scheme that creates regulatory market distortions penalising national producers.

Timing of diagnosis

Problem: Many farmers complain of the difficulty of obtaining a diagnosis in real time, especially in small settings. So often, for practicality, the farmer first employs the choice III antibiotic, whose efficacy is more guaranteed although more risky from a public health point of view.

Historical diagnosis and biogram data

To optimize AMU in animal husbandry and prevent the occurrence of AMR, it is essential that an etiologic diagnosis be ensured as quickly as possible. If the time between the delivery of the sample and the communication of the result is long, the veterinarian is faced with having to set therapy in the absence of a confirmed diagnosis. In these cases in more structured settings (large farms or integrated supply chains), the choice can be directed on the basis of historical data on the trend of AMR/AB susceptibility to the main disease-causing pathogens on the farm. If this system (quali-quantitative monitoring of drug use and relative efficacy) is established over time, historical data are available to draw on to choose the appropriate antibiotic molecule, even in the absence of timely diagnosis.

Problem: This, however, is more rarely the case on small farms, where data recording to set up a farm history is more complex for technical and cultural reasons.

Farmer and veterinarian training

Problem: An additional step that could compromise treatment results is the incorrect use of the drug in terms of timing and amount by the farmer. In this regard, it is important to insist on training the operators who administer the antibiotic. European veterinary drug legislation has created much confusion for farmers, veterinarians, and other stakeholders in the supply chain.

Metaphylaxis (Individual treatments not always possible)

Problem: Pig farming is evolving to larger and larger sizes: the number of herds is decreasing, but the size is increasing (up to thousands of animals). In such a context, the possibility of individually treating positive animals for several consecutive days is not feasible from a practical point of view. Having to stop treatment early due to operational difficulties in individual therapy set on an animal that we know to be sick is more risky in terms of AMR development, compared to a group treatment (metaphylaxis) even of healthy animals but potentially at risk of becoming infected with the pathogen that the boxmate could transmit to them. Partial therapy is not effective from the point of view of resolving the infection and still exposes the germ to selective pressure that can promote the development of resistance.

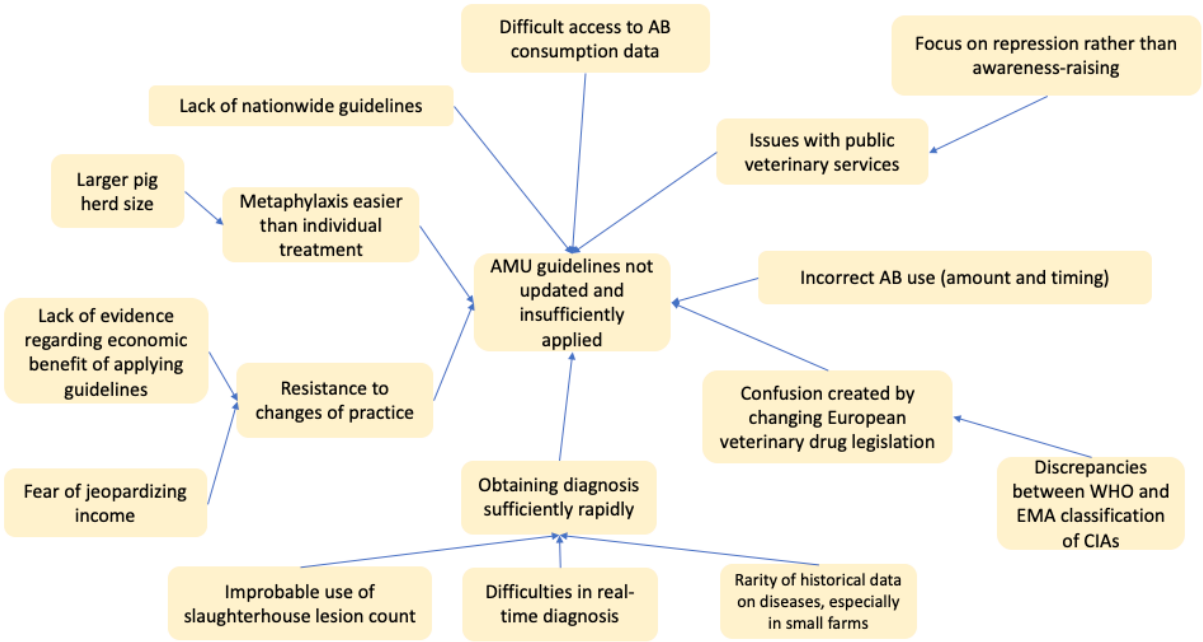

Figure 6.1: Problem tree for the pig sector in Italy

Slaughterhouse lesion count
Problem: Correct diagnosis is essential to set up targeted and effective drug therapy.

Stakeholder consultation and ministry action, uniformity across regions
Problem: In the face of impending legislative changes, there is a need to urge the Ministry of Health to address the issues with unambiguous guidelines at the national level. Unlike other European countries, Italy lacks an active nationwide plan on veterinary drug/AMR use. The importance of a multidisciplinary approach to the problem has not yet been sufficiently captured in our country.

Access to BDN data for research and data sharing among agencies
Problem: The database on antibiotic consumption in Italy, linked to the Electronic Veterinary Recipe (EVR) system, should be public and easily accessible. In fact, the data can only be accessed with prior authorization, without which it is accessible only from the EMA report, published every 2 years. A closed database (without public access) on these issues (including on AMR) has a limited effect: it does not allow its full potential to be exploited, for example in research projects.

Public support for farm counseling and information network between public and private veterinarians
Problem: The role of the public veterinary service must not only be repressive, but it must contribute so that farmers develop an awareness that the consumer they are targeting demands new quality characteristics products, such as reduced antibiotic use or animal welfare protection.

Poultry case study

The problems identified and addressed in the poultry workshop were: a) To consolidate the Italian national strategy to reduce AMU in line with the EU farm-to-fork strategy; b) To support the refinement of the FAO-PMP-AMR poultry-sector specific component for further deployment in FAO Members; c) To assess the progress of implementation of the national AMR activities in the Italian poultry sector; d) To identify agreed actions to be taken in the short term to enhance the level of implementation. Overall there was great progress achieved by the poultry national plan to reduce antimicrobials, and only few problems and actions points were identified by the stakeholders.

6.3 Narrative and impact pathway of the initiative

Pig case study

In the pig sector the participants identified the following action points and the impact pathway is presented in Figure 6.2:

Adoption of the Guidelines in the pig sector.
It would be important for public and private veterinarians to network to share and disseminate positive experiences regarding the implementation of the Guidelines: in the agricultural sector, "word-of-mouth" works a lot, which is more effective than externally issued prescriptions.
The new Rural Development Program programming includes a public grant for advisory services. Dissemination of issues of prudent antibiotic use through this tool should be encouraged. Farmers could be enticed to take advantage of counseling on these issues because it is co-funded.

WHO or EMA classification?
The EMA classification is community-based and more specific to veterinary medicine; therefore, it would be more correct to refer to this when drafting guidelines. One possible obstacle to achieving this is that there is no unified view on this issue either at the national level (the CNR-AR or National Reference Center for Antibiotic Resistance does not share the EMA position) or at the EU level where there is ongoing bargaining, partly conditioned by pressure from pharmaceutical companies, to define future bans on the use of certain molecules.

Timing of diagnosis
The possibility of on-farm diagnosis has not yet been developed in pig farming, but it could be a useful tool to simplify the procedure and speed up response time. Recently, rapid tests have been developed for application in pig farms for diagnostic purposes. The Guidelines could be refined by going more in-depth on the issue of on-farm resistance monitoring (farm history) so that the time to diagnose/set therapy while waiting for laboratory confirmation could be accelerated. The question remains about whether these rapid tests work, how much are they actually used and if they are expensive.

Historical diagnosis and biogram data
The IZS delle Venezie is implementing a platform, freely available for consultation, where AMR/AB susceptibility data from sample submissions to the institute are made available. In this way, even small entities where putting in place a monitoring system is more complicated, can take advantage of historical data referring to their area to set up targeted antibiotic therapy. The problem of AMR can be managed effectively if the hypothesis-diagnosis-identification-communication of the result in real time

pathway is respected or if historical data are available to guide therapy. The ISZ delle Venezie project (platform where the results of different analyses performed in minimum inhibitory concentration (MIC) are shared) is very innovative, also from the communication point of view. It is desirable that other institutions (e.g., IZS della Lombardia e Dell'Emilia Romagna) also develop MIC methods for etiological diagnosis in farm animals and publish the results. The inhomogeneity of the set of molecules tested among different territories made it more difficult for the farm veterinarian to set up treatment plans to be maintained on the farm to carry out initial interventions. At present, several IZSs have jointly defined a set of antibiotic molecules to be tested for antibiotic sensitivity tests in samples from farm animals. In this way, the transition etiologic diagnosis-targeted therapy is made easier for veterinarians working over large territories who can then refer to the same panel of antibiotics in different regions.

Farmer and veterinarian training

It is necessary for institutions to issue clear documents and for farmers to be properly trained to understand them. Training on these issues for all supply chain stakeholders is very important, especially for the farmers who actually administer the drugs. Stakeholders who represent the supply chain in institutions (e.g., European Parliament) also need to be well informed so that they can adequately protect the interests of the sector they represent.

The Emilia-Romagna Region is very involved in this area, both in the initial dissemination of the Guidelines and in other aspects of intensive pig farming (e.g., animal welfare and tail-cutting prevention).

Metaphylaxis (Individual treatments not always possible).

Better and more detailed information and guidance on metaphylaxis is needed in the guidelines. With the entry into force of the new European Regulations, the practice of metaphylaxis is strongly discouraged. The Guidelines must sufficiently clarify when it is appropriate to practice it and when not. In particular, they should answer the following questions: Can the size of the grouping of animals raised be a valid criterion for making decisions in this regard? In very large animal groupings, does the finding of one or a few sick animals justify the use of metaphylaxis to a lesser extent than in smaller groupings? Medicated feeds are often demonized over oral therapy via drinking water. In the reality of pig farming, the water system generally has many leakage points; for this reason, higher dosages than necessary are used to ensure the proper supply of medicine net of leakage. Through sewage, the excess antibiotic in the water can go on to contaminate the environment thus promoting the development of resistance. So for the purpose of AMR prevention, it would be more appropriate to use medicated feeds than administration through water.

Slaughterhouse lesion count.

One tool used successfully in this regard is the assessment of anatomopathological lesions at the slaughterhouse to obtain an estimate of disease prevalence on the farm. This method does not provide a quick diagnosis, but it does provide a picture of the different diseases on your farm so that the veterinarian has objective evidence to set up more specific therapies.

The system collecting information by assessing lesions at the slaughterhouse is certainly effective but only for site 3; it does not apply to site 2 where younger animals are raised and antibiotic use is relevant. The data collection system at the slaughterhouse is good but limited to older animals; on the other hand, it is also true that older animals are also heavier, so antibiotic use is quantitatively important (dosages are high). In addition, pigs spend about 50 percent of their lives (6 months) at Site 3, so the fattening phase greatly affects antibiotic use within the entire life cycle of a pig.

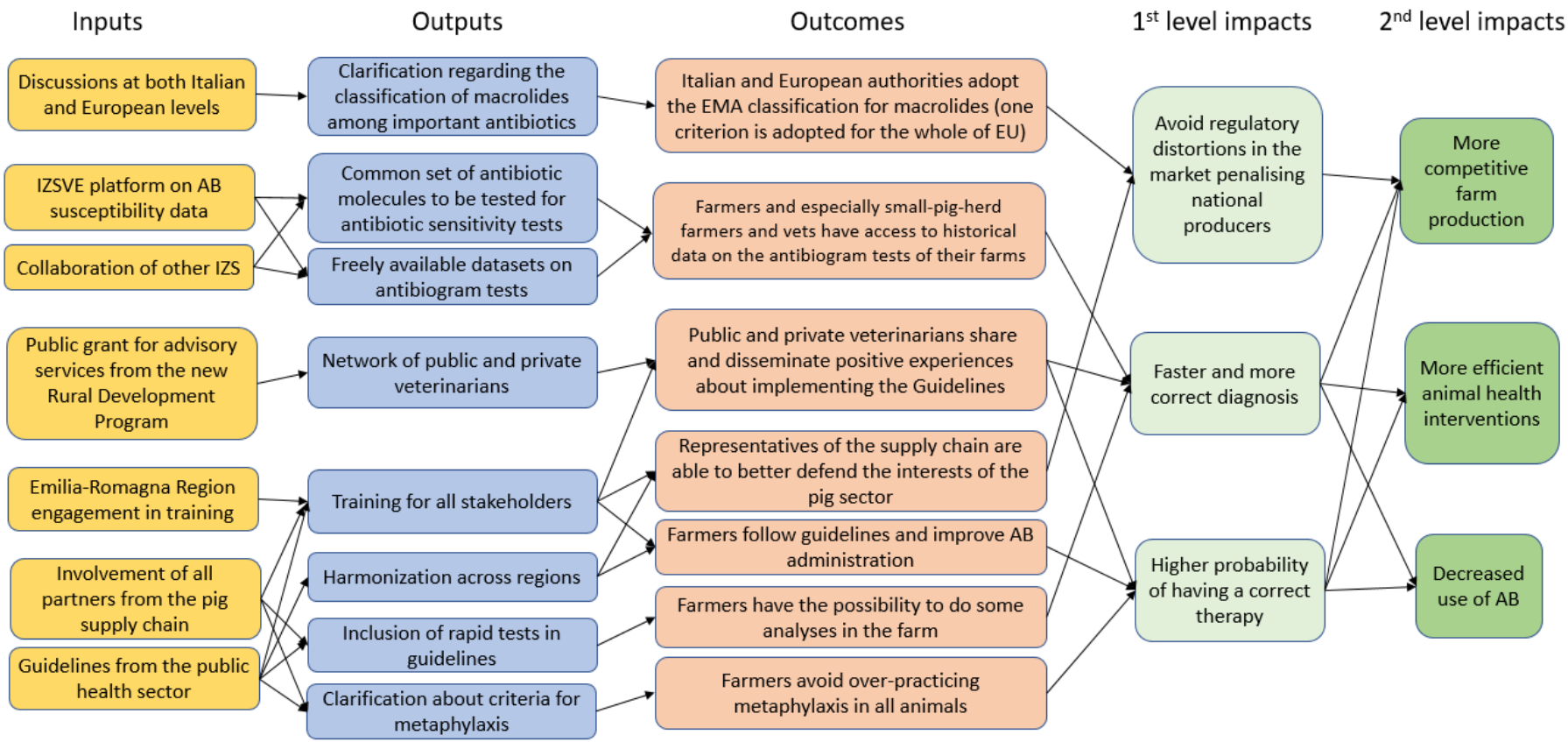

Figure 6.2: Impact pathway for interventions in the pig sector in Italy

Stakeholder consultation and ministry action, uniformity across regions.
It is right for the Ministry to publish outline documents to make policies and guidelines explicit, but more precise guidance is also needed for the regions on how to concretely implement these documents. The technical tables that develop policy documents should involve all partners in the supply chain so as to detect critical points in the system, avoiding distortions due to a partial vision.
The strategies developed by Italy for AMR management include harmonizing MICs among regions (common antibiotic set) and developing public database to provide initial treatment guidance before trial results are available.

Access to BDN data for research and data sharing among agencies.
The sharing of MIC results should be extended to other IZS, in addition to that of the Venezie, involving private laboratories as well. Regarding IZS della Lombardia e Dell'Emilia Romagna project, sensitivity test results should be absorbed directly into CLASSYFARM, so that the history of corporate AMR is maintained in the same system. This would allow both the corporate and public veterinarians to check and keep track of the status of susceptibility to pathogens on the farm where they work. It would also facilitate the setting up of antibiotic use reduction plans and national reporting of data.
One obstacle to the publication/sharing of susceptibility data stems from the fact that these data come from a paid activity; therefore, the boundaries of data ownership would need to be defined and provision made for anonymization before publication. This aspect is a critical point in terms of timing/real-time diagnosis. For all tests that are not required by public veterinary authorities but by private individuals, data ownership needs to be managed.

Public support for farm counseling and information network between public and private veterinarians
In this regard, official inspection must facilitate supply-demand matching. Regarding the public service inspection activity on pharmacosurveillance, a check-list has been developed that contributes to data collection for the CLASSYFARM system through scoring. The check-list was designed to also exert a training function when it is implemented in the presence of farm veterinarian and farmer.

Poultry case study

In the poultry sector the participants identified the following action points:

- Develop AMR surveillance in the poultry sector related environment
- National reporting of AMR surveillance in key bacterial pathogens associated with the clinical cases in poultry at national level
- Conduct standardized testing for AMR and AM residue for the poultry supply chain, and the environment surrounding poultry farms especially water sources
- The National Plan for the poultry sector includes SMART strategic objectives to reduce AMU with a specific target and timeline. However, an integrated budget plan to support the AMR action plan is not developed. Also, it is necessary to publish a report of monitoring and evaluation process on the achievement of SMART strategic objectives
- The workshop participants agreed that more investment is needed to support national research on new alternatives to antimicrobials, prevention, and the impact of AMU on environment, related to the poultry sector

- An initiative of the benchmarking system for individual end-users is not operational. This can guide the high users of antimicrobials toward a more responsible use and was proven effective in other European countries. As there is an integrated system of the Italian Ministry of Health for monitoring the risks relevant to animal welfare, biosecurity, AMU and AMR in farms, called ClassyFarm, the participants agreed on two action points regarding the benchmarking system which could be led by Unaitalia in collaboration with the partners:
    - Adopting benchmarking system for veterinarians and farmers in the wider scope of ClassyFarm
    - Implementing regulation to guide high users identified through the system
- A legislation for the assessment and ranking of farms based on animal wellbeing, biosecurity, and AMU, through a dashboard and color classification (green, yellow, and red, as in other European countries) is under preparation, therefore, it could function to guide farmers toward the prudent use of antimicrobials. Another consideration is that there is no regulation on waste management and wash water/slurry associated with AMR/AMU in the poultry sector
- AMR education is not covered with specific teaching courses in the curriculum of agricultural schools and universities, but the topic is treated in the courses of some disciplines
- Participants agreed to the need to assess the level of education on AMR at high schools for agriculture operators, possibly getting in touch with the Ministry of Education

6.4 Impact indicators for the initiative

Pig case study

The following indicators of change were identified to verify the efficiency of interventions included in the initiative:

WHO or EMA classification?

- Change to EMA classification in guideline (or macrolides reclassified in accordance with EMA)

Timing of diagnosis

- Reduction in diagnostic time (a strategic plan will be developed to monitor diagnostic times)

Historical diagnosis and biogram data

- Standardization (nationwide) of methods and molecules for MICs
- IZSVE platform implemented and integrated with CLASSYFARM for nationwide use

Farmer and veterinarian training

- Creation of specific training for the farmer in AMU/AMR in accordance with new EU legislation
- Creation of specific training for veterinarians in AMU/AMR in accordance with new EU legislation

Metaphylaxis (Individual treatments not always possible).

- Adaptation of guidelines to the new European regulations
- Creation in the guideline of a chapter devoted exclusively to metaphylaxis, with detailed indication and alternative replacement practices to metaphylaxis

Slaughterhouse lesion count.

- Integrate slaughterhouse lesion infection data based on CLASSYFARM or IZSVE
- Data available to veterinarians

Stakeholder consultation and ministry action, uniformity across regions.

- Creation of a supply chain committee at the center of the Ministry of Agriculture (or Health) to debate the national plan/strategies on veterinary drug use/AMR
- Training provided by the Ministry to the regions (regional veterinarians) for standardization of guideline practices.
- This same 1st 'workshop' promoted by UNIBO in collaboration with the Ministry is a technical discussion table for updating the Guidelines.
- The 2nd workshop to be held in 2022 will also serve as an indicator of integration of supply chain stakeholders on policy discussions and development of guideline documents

Access to BDN data for research and data sharing among agencies.

- Creation of databases with MIC results on CLASSYFARM
- Granting access of these data to all actors in the supply chain, including those responsible for research and teaching (of new veterinarians, animal husbandry, agronomists and farmers, etc.).

Public support for farm counseling and information network between public and private veterinarians

- Training provided by public veterinarians to farmers and farm veterinarians on the CLASSYFARM checklists
- The possibility for the farmer and corporate veterinarians who received a low score on the check-list, to substitute the first penalty for participation in the training

Poultry case study

In the poultry sector, the main action points agreed among stakeholders are:

- Assess the level of education at high school for agriculture operators (preliminary study or initiative at small scale)
- Review/ Develop AMR surveillance in the poultry sector related environment
- National reporting of AMR surveillance in bacterial pathogens associated with the clinical cases in poultry at national level
- Conduct AM residue testing in environment related to the poultry production
- Allocate national funding on AMR/AMU research in poultry sector
- Benchmarking system for veterinarians through ClassyFarm
- Implementation of regulation to guide high users identified through the benchmarking system

7 ROADMAP initiative in Vietnam

Course of the work

In Vietnam, ex-ante impact assessment activities were delayed owing to the Covid-related border closure which meant that Chloé Batie could only go there in November 2021. Preliminary interviews were conducted from December 2021 to February 2022 with farmers, drug sellers, and traders of the study area (Bao Ly commune, Phu Binh district, Thai Nguyen province). Three workshops were then organized in April 2022 with one workshop organized per week.

Half of the participants were recruited based on the preliminary interviews. Fifteen people participated in the workshops including 2 representatives of the Sub-department of Animal Health, 1 representative of the district veterinary station, 1 communal veterinarian, 1 integrated farm (that uses herbs to feed the chickens), 5 independent farmers (including two farmers that have reduced their ABU), 1 traditional trader, 1 representative from a drug and alternative products company, 2 drug sellers, 1 researcher. The participants were the same during the first two workshops. For the last workshops, three participants were replaced by three other participants belonging to the same category of actors.

7.1 Initial assessment

General context of AMU in Vietnam

In response to the Global Action Plan on antimicrobial resistance adopted in May 2015 at the World Health Assembly, the "National Action Plan for management of antibiotic use and control of antibiotic resistance in livestock production" has been established in 2017 under the Ministry of Agriculture and Rural Development in Vietnam for the period 2017-2020 (MARD's Decision 1399/QD-BNN-TCCB dated 13 April 2017). This plan has been drafted by the sub-committee on "Drug resistance in agriculture" that is under the National Steering Committee for Prevention and Control of Drug Resistance (established by the Ministry of Health after the National Action Plan (NAP) on combatting drug resistance from 2013-2020). The new NAP 2021 – 2025 was released in 2021.

The NAP includes the improvement of legal documents for AMR and AMU management. Since then, regulatory changes have been established, notably the ban of antibiotics as growth promoters in 2018 (implemented in 2019). Further measures are ongoing such as the progressive complete ban by 2025 of antibiotics in the feed for prevention purposes. More recently, the circular on regulations on the prescription of veterinary drugs has been signed in November 2020, making prescription mandatory to buy antibiotics in veterinary medicines. A roadmap has also been established on the same topic, starting to target large-scale farms until reaching the household level as well by 2025. Indeed, in Vietnam, antibiotics are easily affordable and are available over the counter from various drug sellers.

Besides changes in AMU policy and AMR surveillance system, Vietnam is also facing important developments in the animal sector. Due to rapid economic and demographic growth, the need for animal protein has increased. To adapt to these changes, the animal sector is experiencing an intensification of farming practices promoted by the government (Decision Approving the Master plan on agricultural

restructuring in the 2021-2025 period). This phenomenon has led to increased consumption of inputs, including antibiotics. Very little information is available on AMU in livestock production but it has been estimated that the total antimicrobial use in 2020 was 1016,23 tonnes and it was expected to reach 1170,90 tonnes by 2030 (Sriram et al. 2021).

Poultry production in Vietnam

The number of chickens in Vietnam is continuously growing (J.D. Cesaro et al., 2019) and reached 317 million of heads in 2018 (FAOSTAT, 2018)). Various production systems exist from backyard production, where limited numbers of chickens are raised in free range, to intensive contract farms with thousands of broilers or laying hens. Most of finished antibiotics products are imported or manufactured in Vietnam from imported raw products. Depending on the production system, the supply and the source of advice to use antibiotics vary greatly. Distributors can sell drugs directly to large scale contract farms or to veterinary drug agencies. But, most of the familial commercial or backyard farms buy antibiotics directly through agencies (distributor level 1) or in drug shops (distributor level 2). For integrated farms, the largest part of their drugs is coming from the integrator. A network of illegal importation and distribution of antibiotics exists in Vietnam. Another issue concerns the low drug quality linked to insufficient controls by the authorities. The implementation of the new legislations will take time because of the scarce on-farm control and the gap between the legislation and practices.

Studies that have been conducted until now in Vietnam showed an overuse and misuse of antibiotics in chicken farms in all production systems, such as the use of forbidden antibiotics like chloramphenicol (Kim et al., 2013). Studies point as well a high percentage of self-medication (Pham-Duc et al., 2019) that can be easily practised thanks to an easy drug access without prescriptions and without diagnosis (Phu et al., 2019). Antibiotics are mostly used as preventive methods (a study published in 2015 by Carrique-Mas et al. found that among 208 chicken farms in the Mekong Delta, 84% of antibiotics were used to prevent diseases) but also as growth promoters.

About antibiotic resistance in chicken production, a study conducted in the Mekong Delta in 2012 showed that all the isolates of Campylobacter spp. from 343 pork and poultry farms where resistant to erythromycin, 99% to sulfamethoxazole-trimethoprim, 92% to nalidixic acid and ofloxacin and 20.8% to ciprofloxacin (Carrique-Mas et al., 2014). Moreover, high percentages of chicken meat with antibiotics residues were found in the cities of Ho Chi Minh and Nha Trang between 2012 and 2013: 70,3% of chicken meat samples were positive to at least one antibiotic (Yamaguchi et al., 2015). Farmers also observe a decrease in the effectiveness of antibiotics and they often need to change antibiotics after a few days of treatment. They also report a higher disease prevalence and more difficulties to treat them.

Regarding the organic production, several standards exist including foreign labels (from the United States and the European Union) and a participatory guarantee system (PGS) and a national standard (to our knowledge no chicken farms have this national standard label and the PGS for the moment). Some companies and independents have also decided to meet the international demand and the wealthiest citizens in urban areas, to produce higher quality chickens fed with herbs or probiotics. VietGAHP (Vietnam Good Animal Husbandry Practices) represents the national standard for meat production. The process is totally voluntary and private organisms related to the government are in charge of controlling the respect of the requirements by the farmers.

7.2 Problem(s) addressed by the initiative

Participants have identified five main objectives that they would like to reach in 10 years to reduce and improve the use of antibiotics: 1) Better access to products such as herbs, probiotics or natural products as substitutes for antibiotics; 2) Strengthen farmers' awareness about technology, about the harmful effects of antibiotic resistance; 3) The need to eliminate the small-scale husbandry system and focus on raising poultry on a larger scale; 4) Control and manage the production of antibiotics and the circulation of drugs on the market. 5) The need for a biosecure farming model and organic farming. The point 4 was identified as too complicated to be addressed by the group.

Based on the previous points, the common vision that the participants developed was: *In 10 years, we would like biosecurity and organic farms using alternative products, and training for the farmers about techniques and disadvantage of antibiotic resistance.*

The long-term impacts they wanted to contribute to were the reduction and better use of antibiotics in livestock production and the improvement of livestock farming practices.

The short-term impacts were:

- Increase the use of alternatives to antibiotics (feed additives, essential oils, herbs, …)
- Development of antibiotic-free production channels or organic production channels
- Improvement of biosecurity at the farm level
- Compliance with international standards
- Access to safer products for consumers

When exploring the barriers that prevent the achievement of the vision, the participants identified four main branches: lack of output for organic products, lack of knowledge and awareness on biosecurity and organic farming, low compliance of small-scale farms on biosecurity, and lack of science and technology related to alternative products. Those branches included 30 problems (see Figure 7.1).

Lack of outputs for organic products

It is expensive for farmers to produce organic chickens and complicated because the access to organic feed for chickens is rare in Vietnam. It is also more expensive because farmers need to use other farming methods. Another problem related to the organic production is the lack of outputs for those quality products. They are sold for a standard price so there is no financial compensation for the higher production cost. It should also be noted that traders, who buy chickens directly to farmers and sell them on local markets, do not want to buy them for a higher price (when farmers use herbs or probiotics). The main reason is that consumers do not want to pay for a higher price because they cannot see the difference between those products and standard products. As of today, traders buy chickens according to their appearance and not according to the way of production. An organic national standard has been created but it has so far not been used in practice because it is not well adapted to the situation, because the certification process is quite expensive and because there is a lack of certifiers in Thai Nguyen province. This problem is also related to the lack of consumers' awareness about biosecurity and organic production. They are not used to buying groceries in supermarkets where it would be easier to know which products are organic or not.

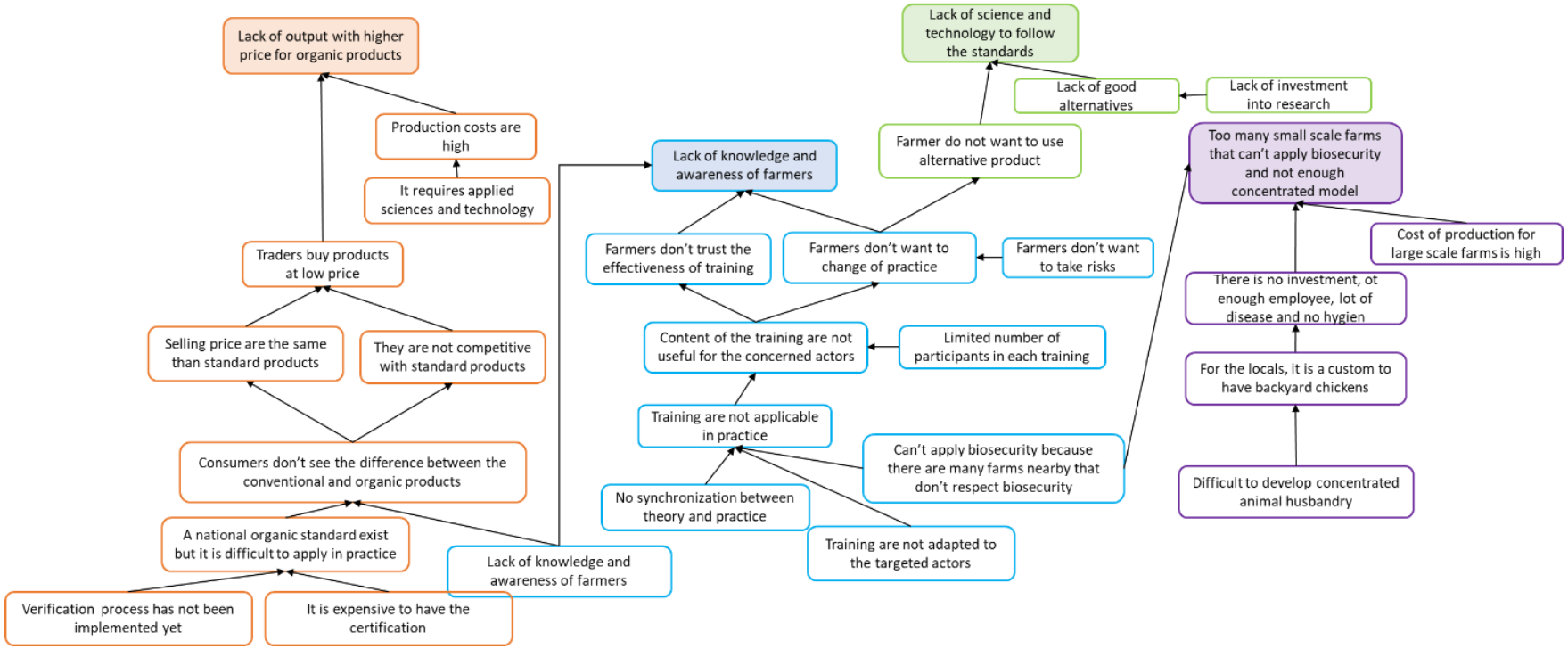

Figure 7.1: Problems preventing the achievement of the common vision on developing organic production, biosecurity and alternatives to antibiotics in poultry production in Vietnam

Lack of knowledge and awareness on biosecurity and organic farming

This is connected to two main problems: famers do not want to change because they do not want to take any risk but also because they do not believe in the training. The weight of habits is really important and most farmers are reluctant to change their practices. When farmers come to a seminar, they are more interested in bringing their chickens to know how to treat them rather than improving their farming practices. Another point is that current trainings are not adapted to the situation of the farmers and do not correspond to their reality. The consequences are that farmers cannot apply the training recommendations in practice so there is a lack of useful training for those farmers even if there is a lot of training programs organized by the states and also by private companies. Farmers also do not have enough knowledge to raise chickens differently. Because veterinarians and drug companies focus on treating diseases rather than preventing them, they do not provide advice related to biosecurity to farmers.

Low compliance of small-scale farms on biosecurity

In Vietnam, small scale production is the most common poultry farming system. Those farmers have a limited knowledge in farming practices including biosecurity measures. Those farms are not concentrated in one area and the chickens can move everywhere freely. People's houses and farms are in the same area and people go from one farm to another without applying any preventive measure to reduce disease transmission. Moreover, investment is very limited and farmers do not hire any employee that could help them apply biosecurity. As they do not apply biosecurity measures, they are at risk from the other farms that in turn do not want to apply biosecurity if their neighbours do not. There is a lack of synchronization in the farming technics improvement. This way of producing chickens is related to the customs of the country: having few free-range chickens. It is also linked to a perception that the cost of production to develop a large farm is too high.

Lack of sciences and technology related to organic products

The quality of alternative products is not high enough and farmers do not want to use them because they are afraid of change. When treating chickens, farmers but also veterinarians want to see immediate effects and often want to a solution without having to go through a complete diagnosis process. Moreover, farmers lack knowledge on how to use alternative products.

7.3 Narrative and impact pathway of the initiative

Participants have chosen to develop action plans that will contribute to address the following problem: *"lack of awareness and training of farmers on organic production and biosecurity"*. Indeed, this problem has been raised several times during the construction of the common vision and the identification of the problems. However, it has to be noticed that the second most important choice concerned the small-scale farms that do not comply with biosecurity. But, by addressing the problem on the lack of training on biosecurity, this problem can be partially solved if small-scale farms are the target.
Even if the lack of output for organic products hasn't been chosen by the participants, it has been discussed intensively during the three workshops.

Inputs and outputs

In order to address this problem, training programs focusing on alternative products, organic production and biosecurity should be provided to farmers but also to drug sellers, veterinarians and companies to a larger scale. Those programs should feature contexts and work environments that are close to reality. To that purpose, participants of the workshop designed two action plans during the last session of the workshops.

First, to be able to have access to a large number of participants, **training programs should be diffused through social media or TV.** Training materials (such as short videos) will be developed by companies without having to conduct a proper seminar. To make sure that these videos meet the expectations of the target, surveys to assess the needs of farmers should be conducted prior to developing the training materials. The targets of these programs will be farmers and consumers (two different programs). The topic of the training will be on organic farming, biosecurity, and alternative products. But also, it will highlight the benefice of using less antibiotic and producing safe products and compared to standard products. Programs will also include the visit of some model biosecurity and organic farms. Programs will be diffused on TV channels at the national level (VTC 16, VTV 2) and local TV channels twice a week at 8pm.

The second communication channel should be social media (Facebook, Instagram, Zalo). Funding will come from the Vietnamese government and from foreign organizations. The production units will be the TV channel and the content will be orientated by the Ministry of Agriculture and associated agencies (Department of Livestock Production, National Agricultural Extension Centre, Department of Agriculture and Rural Development, Department of Sciences and Technology, Thai Nguyen University of Agriculture and Forestry).

The second plan is to provide better training on biosecurity and organic production to drug sellers. The targets of this program are the retailers of drug shops (retailers and veterinarians that sell drugs at the drug shop or directly from the farms). The topics are as follows: principles of using antibiotics in livestock farming, disadvantages of overusing antibiotics, the process of biosecurity and organic farming and guidance to use alternative products. The people responsible for providing the training will be the veterinary medicine companies, technicians and agricultural extension officers of the Agricultural Service Centres, lecturers from universities that have a faculty of veterinary medicine (in this case, Thai Nguyen University of Agriculture and Forestry), and the Sub department of Veterinary Medicine and Aquaculture.
They will have to follow an approved program and the company will approve the schedule for the training courses. Training will be organised twice a year but also when epidemics will occur, when there is a new product and when they will be new staff members at the drug shops. It will be possible to organize this training at the commune level, at the district level, or at the farm level (they will be able to observe the farm environment). Diffusion will be possible in person or online. Fliers will also be given to participants. Participatory formats will be encouraged for meetings, for example by mixing serious games, presentations and group discussions.

Inputs and outputs are graphically presented on Figure 7.2 together with outcomes and impacts.

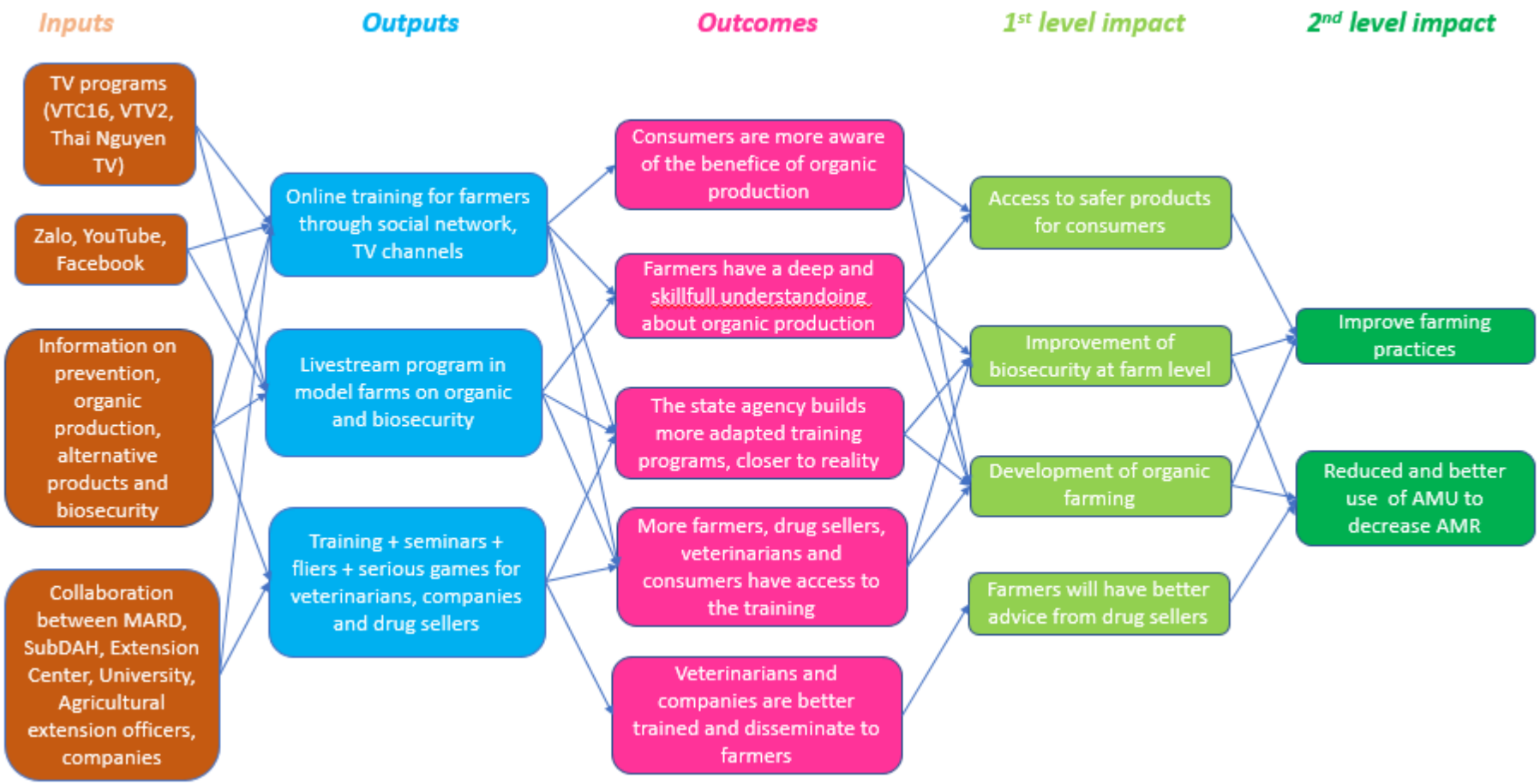

Figure 7.2: Impact pathway of the initiative in Vietnam to improve the training on bioecurity and organic poultry production

Outcomes and impacts

By developing an online training program on mass media channel at appropriate times, it is expected to reach a large number of farmers and consumers. Moreover, given the broadcasting time and the short format, farmers will have the time to watch it.
It is expected that this program will contribute to guide farming practices toward biosecurity and organic production by providing deep knowledge and practical examples to the targeted audience. The training will be closer to reality (by giving some examples through model farms) and more adapted to the farmer's work environment. Farmers will know how to improve the product quality and the price they will obtain for their production will be higher. But it will also raise the awareness of the consumers that will be more willing to buy safer products at a slightly higher price (in supermarkets). Many farmers will have access to biosecurity and organic farming.

By focusing the training on retailers, it is expected to raise their awareness regarding biosecurity and organic farming. In Vietnam, drug retailers and farmers have a close relationship. Even if in the end, the person that makes the decision to buy and use antibiotics is the farmer, drug retailers have a certain level of influence on them. By increasing the knowledge of retailers, they will be in capacity to provide better advice to farmers and to orientate the production into this desired direction. Also, by developing such programs at the drug store or locally, it will increase the number of participants who can in turn diffuse this knowledge to other retailers.

The first impact of those two training programs will be to produce safer products for consumers. It will orientate the farming direction toward biosecurity and organic production. And farmers will receive better advice from retailers and will be more compliant to apply their instruction.

At the end, the long-term impacts will be contributions to reduce and improve the use of antibiotics in chicken production in Vietnam as well as to improve farming practices.

7.4 Impact indicators for the initiative

We didn't address this issue in the workshops held so far in Vietnam. Impact indicators will be designed by stakeholders as implementation of the initiative progresses.

8 Conclusion

The five countries involved in ex ante impact assessment have different contexts and targeted different types of production. The process of building a desired vision for the future, identifying problems preventing the desired impacts from happening, and designing strategies to address these problems resulted in a large variety of impact pathways for ROADMAP initiatives.

The next step of WP6 activities will be to perform a transversal analysis of these impact pathways and establish generic recommendations for broader, long-lasting and context-adapted transition pathways towards prudent AMU.

9 List of references

ANSES, 2021. Surveillance des ventes de médicaments vétérinaires contenant des antibiotiques en France en 2020. 92 pages. https://www.anses.fr/fr/system/files/ANMV-Ra-Antibiotiques2020_0.pdf

ANSM, 2017. L'évolution des consommations d'antibiotiques en France entre 2000 et 2015. Agence Nationale de Sécurité du Médicaments et des produits de santé. 44 pages. https://www.omedit-grand-est.ars.sante.fr/system/files/2017-08/ANSM-rapport-antibio_2016_bd2.pdf

Carrique-Mas, J.J., Bryant, J.E., Cuong, N.V., et al., 2014. An epidemiological investigation of Campylobacter in pig and poultry farms in the Mekong delta of Vietnam. Epidemiol. Infect. 142, 1425–1436. https://doi.org/10.1017/S0950268813002410

Carrique-Mas, J.J., Trung, N.V., Hoa, et al., 2015. Antimicrobial Usage in Chicken Production in the Mekong Delta of Vietnam. Zoonoses Public Health 62, 70–78. https://doi.org/10.1111/zph.12165

FAOSTAT, 2018. Food and Agricultural Organization Statistical Database: Live Animals http://faostat.fao.org

Cesaro J.D., Duteurtre G., Nguyen Mai Huong, (Coord.), 2019. Atlas de la transition de l'élevage au Vietnam (1986-2016). IPSARD-CIRAD.

Kim, D.P., Saegerman, C., Douny, C., et al., 2013. First survey on the use of antibiotics in pig and poultry production in the Red River Delta region of Vietnam. Food Pub Health 3(5), 247–256. https://doi.org/10.5923/j.fph.20130305.03

Perrier, A., Hainaut, P., Lamy, P. J., et al., 2022. Clinical use and evolution of circulating biomarkers in the era of personalized oncology: From protein markers to bioclinical scores. Bulletin du cancer 109 (2) 151-169. https://doi.org/10.1016/j.bulcan.2021.11.010

Pham-Duc, P., Cook, M.A., Cong-Hong, H., et al., 2019. Knowledge, attitudes and practices of livestock and aquaculture producers regarding antimicrobial use and resistance in Vietnam. PLoS ONE 14, e0223115. https://doi.org/10.1371/journal.pone.0223115

Phu, D.H., Giao, V.T.Q., Truong, D.B., et al., 2019. Veterinary Drug Shops as Main Sources of Supply and Advice on Antimicrobials for Animal Use in the Mekong Delta of Vietnam. Antibiotics 8, 195. https://doi.org/10.3390/antibiotics8040195

Sriram A., Kalanxhi E., Kapoor G., et al., 2021. State of the World's Antibiotics 2021: A Global Analysis of Antimicrobial Resistance and Its Drivers. The Center for Disease Dynamics, Economics & Policy; Washington, DC, USA https://cddep.org/wp-content/uploads/2021/02/The-State-of-the-Worlds-Antibiotics-in-2021.pdf

Yamaguchi, T., Okihashi, M., Harada, et al., 2015. Antibiotic Residue Monitoring Results for Pork, Chicken, and Beef Samples in Vietnam in 2012–2013. J. Agric. Food Chem. 63, 5141–5145. https://doi.org/10.1021/jf505254y