ROADMAP

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

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Impact assessment case studies selected and documented

Sophie Molia[1*], Merete Studnitz[2]

[1] CIRAD, France; [2] ICROFS, Denmark

* Deliverable leader – Contact: sophie.molia@cirad.fr

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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*

Table of contents

List of acronyms and abbreviations

AB	Antibiotics
ADAM	Association of the poultry farmers of the Province of Maputo (Mozambique)
AM	Antimicrobials
AMCRA	Centre of Expertise on Antimicrobial Consumption and Resistance in Animals (Belgium)
AMR	Antimicrobial resistance
AMU	Antimicrobial use
BVK	Beroepsvereniging voor de Belgische Kalfsvleessector (Belgium)
CDDEP	Center for Disease Dynamics, Economics and Policy
DGAL	General directorate of food at the Ministry of Agriculture (France)
EBSL	Extended spectrum beta-lactamase-producing bacteria
EFSA	European Food Safety Authority
ESVAC	European Surveillance of Veterinary Antimicrobial Consumption
FAMPH	Federal Agency for Medicine and Health Products (Belgium)
FAO	Food and Agriculture Organisation of the United Nations
FHP	Farm Health Plan (The Netherlands)
FTP	Farm Treatment Plan (The Netherlands)
GARP	Global Antibiotic Resistance Partnership
HC	Dutch Health Council (The Netherlands)
IHR	International Health Regulation
JEE	Joint External Evaluation
KNMvD	Veterinary professional organisation (The Netherlands)
LL	Living lab
MRSA	Methicillin-resistant Staphylococcus aureus
NAP	National One Health action plan (Italy)
NGO	Non-governmental organisation
NPA-AMR	National Action Plan for an effective AMR intervention (Mozambique)
NVWA	Dutch Food and Consumer Product Safety Authority (The Netherlands)
OIE	World Animal Health Organisation
OUA	“Pure pork” pigs raised without any antibiotic (Denmark)
PCU	Population Correction Units (Italy)
PO	Producers’ organisation (France)
PVE	Product Boards for Livestock, Meat and Eggs (The Netherlands)
SDa	Dutch Veterinary Medicines Authority (The Netherlands)
TAM-V	Tierarzneimittelvereinbarung (Switzerland)
TTF	Targets task force (United Kingdom)
WHO	World Health Organisation of the United Nations
WVAB	Veterinary Antimicrobial Policy Working Group (The Netherlands)

1 Summary

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.

Nine countries of the ROADMAP project are engaged in some form of ex ante impact assessment, either as a short or full process, the description of which can be found in Milestone 31.

The first step of the process was to understand the general context of AMU in each country and in particular for the type of production considered in each case study (marginal poultry in Mozambique, turkey in The Netherlands, conventional pigs and calf/beef cattle in Switzerland, marginal cattle in the United Kingdom, conventional pigs in Belgium, organic and conventional pigs as well as organic dairy in Denmark, conventional pigs and poultry in France, conventional and label pigs as well as conventional poultry in Italy, and marginal poultry in Vietnam). Information was collected through white and gray literature review and consultation of experts.
National plans or programs aimed at improving AMU in animal production have been set up in all countries mainly in the 2010s and sometimes earlier. Nevertheless, the ability to monitor AMU differs widely between countries from no or little data available to farm-level data available in public databases. AM legislation and private-sector-led AMU reduction initiatives also varied greatly among countries. However, there were similarities in health constraints for which decreasing AMU proved difficult (for example post-weaning in piglets or specific ages for poultry).

The second step of the process was to identify stakeholders and to review data on stakeholders' behaviours, practices, knowledge and motivations. This was achieved through a series of interviews with key stakeholders (implemented for WP1) and sometimes surveys of farmers and veterinarians (implemented for WP2).
Some stakeholders' maps have already been produced and others are in the process of being validated. They show the large number of actors involved and the complexity of the relationships between them. Diverse and sometimes contradicting attitudes were found: decreasing AMU could seem undesirable out of animal welfare concern, fear that premium price paid for AM-free animals would decrease, a perceived unability to address health issues without AM, or fear of losing income vastly dependent on AM sales.

The third step consisted of identifying the AM-related impacts stakeholders wished to contribute to through the ROADMAP project, as a preliminary to the core ex ante impact assessment steps (identifying a desirable future and desirable impacts, building a problem tree and a map of outcomes). Only two countries (Belgium and Denmark) out of the five involved could start this process, as organising LL proved difficult because of the Covid-19 situation. Other countries will start this step in the upcoming period.

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 is to **improve the construction of these interventions/solutions** by designing them in a strategic and participatory manner and **laying out the mechanisms through which impacts will be generated**.

Four countries of the ROAMAP project (Mozambique, Switzerland, the Netherlands and the United Kingdom) are engaged in **a short ex-ante impact assessment** consisting of identifying stakeholders' desired impact. For that purpose, they need to produce a stakeholders' map, review data on stakeholders' behaviours, practices, knowledge and motivations and ask stakeholders about impacts through questionnaires or through participatory workshops.
The selected case-studies for short ex ante impact assessment are as follows: Mozambique on marginal poultry, The Netherlands on turkey, Switzerland on conventional pigs and veal/beef cattle, and the United Kingdom on marginal cattle.

Five countries of the ROAMAP project (Belgium, Denmark, France, Italy and Vietnam) are engaged in **a full ex-ante impact assessment** consisting of identifying stakeholders' desired impact (as described previously for short ex-ante impact assessment), building a problem tree and a map of outcomes, and producing impact pathways and impact indicators. These activities are closely intertwined with the living labs (LL) of WP3.
The selected case-studies for full ex ante impact assessment are as follows: Belgium on conventional pigs, Denmark on organic and conventional pigs as well as organic dairy, France on conventional pigs and poultry, Italy on conventional and label pigs as well as conventional poultry, and Vietnam on marginal poultry.

3 Short ex-ante impact assessment case-studies

3.1 Mozambique

3.1.1 Presentation of the case study

General context: Antimicrobial resistance (AMR) policy in Mozambique

The engagement of the Mozambican authorities on AMR is recent and has been stronlgy supported by the international community. In 2016, the Mozambican Government designed a National Action Plan for an effective AMR intervention (the NPA-AMR, officially adopted in 2019). This plan was built on a previous situation analysis conducted by the Global Antibiotic Resistance Partnership (GARP)-Mozambique, a team of academic scientists, health professionals and other stakeholders, supported by the Center for Disease Dynamics, Economics and Policy (CDDEP) and funded by the Bill and Melinda Gate foundation. The NAP-AMR also benefited from the Joint External Evaluation (JEE) of IHR (International Health Regulation) Core Capacities (WHO 2017) and the expertise of the OIE Veterinary legislation support programme (VLSP), (OIE et al. 2015), both including a section related to AMR.

However, very little information is available on AMU and AMR in Mozambique. In human medecine, the rare studies show resistances to chloramphenicol, ampicillin, penicillin and cotrimoxazole (GARP Mozambique et al. 2015). But no data are available for the animal sector. It is suggested that there is a large misuse of AB in the animal sector (GARP Mozambique et al. 2015, OIE et al. 2015), encouraged by a very weak regulation on veterinary medicines. At the same time, even if most Mozambican farmers still have a limited access to veterinary drugs, importations of AB (there is no local production) is said to increase, in particular to answer to the growing sector of poultry farming (the national production has doubled during the last 10 years, to reach around 90 000 tons in 2018, source : FAOstat).

On this basis, the NAP-AMR concludes to the urgent need to address the veterinary use of AM in Mozambique and proposes to give priority to the strengthening of the regulation on veterinary medicines and the implementation of a "Best Practice Guidelines" in the poultry production sector. The objective of the Roadmap Mozambican case study is to support the implementation of the NAP-AMR in the poultry sector, in collaboration with the association of the poultry farmers of the Province of Maputo (ADAM) and the Dinav (the veterinary national authority).

There is no technical innovations at the moment being implemented in Mozambique to reduce AMU (no organic or AM free poultry). Innovations are related to the policy and regulatory process (revision in progress). In addition, the topic of AMR is being progressively included in the training of the veterinarians and zootechnicians.

AM market chain and poultry sector in Mozambique

According to our own study, the veterinary drug supply chain in Mozambique is characterized by a duality. There is, on one side, a vibrant private sector supporting and supplying the development of the growing commercial and industrial poultry production, based on imported drugs (mainly from Portugal, Netherland, France, Brazil, very often through South African distributors). There is on the other side a quite weak public sector (backed by donors, international organizations and NGOs) supporting, in a more or less regular way, the vast majority of small-scale poultry farmers, mainly through vaccination campaigns.

The available estimations of national veterinary AMU are based on the demands addressed by importers to the Ministry of Agriculture; this data are used to build the report addressed annually by that Ministry to the OIE (reporting option 1, meaning that there is no information available per species), mainly penicillin, tetracyclins and macrolides. There is also probably a significant amount of cross-border trade of veterinary drugs coming from South Africa, which escapes this reporting. The consumption of drugs for the aquaculture production -limited to 1 800 tons in 2017- (Instituto Nacional de Estatística 2018) escapes also that assessment since aquaculture depends on the Ministry of Fisheries and Aquaculture. It is likely, according to experts and drugs sellers, that AB are mainly consumed by the poultry sector, and more precisely by the commercial poultry sector.

There is no specific law on veterinary drugs and the animal health regulation does not cover the veterinary drugs. There is a "regulatory framework for pharmaceuticals" under the responsibility of the Ministry of health but that in practice focuses on human drugs. The trade of veterinary drugs is framed by law (on imports, trade etc…) which are not specific to drugs. Officially, only veterinary drugs listed on the "Formulario veterinario" are allowed to be used in Mozambique (Diploma Ministerial N° 57/86 de 29 de Outubro 1986). This list includes 159 products, including 22 AB products.

According to the authorities, the use of AB as growth promotor is forbidden (but it is unclear under wich regulation). Prescription is not required to buy AB. There are few veterinarians in Mozambique in particular in rural areas (according to the Wahis-OIE database, there would be around 380 veterinarians in Mozambique in 2018). Therefore, AB can be sold anywhere, anyhow and to anyone.

Veterinary drugs retailers are central actors in the supply of drugs for farmed animals. This category embraces a large diversity of stakeholders, including a large number of non-professional ones, often involved in selling various farm inputs ("agro dealers") or specialized in poultry farming. Consequently, many poultry farmers mainly receive advice from sellers with no formal training and with little knowledge (and often no knowledge at all) on AMR. Only the few companies operating at national scale (e.g. Highest, Irvine…), have a web of qualified drugs retailers receiving regular training, including on AMR.

According to our survey among drugs sellers, AB and vitamins are the most sold products: famers are more likely to use preventively AB than to vaccinate their flock. It is estimated that 85% of the poultry (backyard and commercial) are not vaccinated against Newcastle disease in the country, and in the case of the Zambezi Province 20 to 24% of the commercial poultry production would be lost, mainly due to Newcastle disease (ADB 2019).

3.1.2 Identification of stakeholders' desired impacts

At the moment , most activities of the Mozambique case study have focused on the analysis of the organisation of the veterinary drugs suply chain in general. Interviews with stakeholders of the veterinary drug market chain have been conducted (with importers, wholesalers and retailers, clinic etc.). Interviews with stakeholders of the public sector are in progress. More work is needed to allow the systematic analysis of stakeholder's behaviours and to understand the strategies and power relationships.

We have identified the structure and part of the functioning of the distribution of veterinary drugs and antibiotics in Mozambique, from importers to drugs retailers, and drawn the market chain supplying Maputo Province where the farms of our case sudy are located. Two supply chains have been identified: 1) private (formal and informal), 2) public supported by donors and NGOs. The list, including AB available on the market (origin, brand and price) has been collected at retailing points. The quantification of the flows of AB in the market chain has not been completed.

The partners of the project are the association of the poultry farmers of the Province of Maputo (ADAM) and the Dinav (Direction of veterinary services, Ministry of Agriculture). The main impacts expected from the Roadmap project by these partners are: for Dinav, a support in implementing the National action plan, and more particularly in better quantifying veterinary AMU in Mozambique; for the ADAM members, a support in animal health through exchanges on a better use of veterinary drugs (beyond AMU). A travel in La Réunion is planned for an exchange of experience with French poultry farmers, much expected by ADAM representatives but difficult to plan in a Covid-19 context.

3.2 Switzerland

3.2.1 Presentation of the case study

General context

In 2015, Switzerland implemented a programme to decrease the use of antibiotic in livestock production. However, there is no statistics about the use on farm. This is still work in progress. Data available cover the quantity of antibiotics sold. The sale of antibiotics decreased since 2010 by about 52% (33,197 kg). This decrease is mainly based on a decline in drug premixes sales for group treatments. In general, it seems that the use of antibiotics has become more targeted. But veterinarians earn money with the selling of antibiotics to farmers. A significant limitation is that the interpretation of the distribution data is limited in terms of effective treatments for specific animal populations, as most of the preparations are approved for several animal species.

Currently, there are no policy instruments to incentivise a reduced use of antibiotics. An instrument developed by the government is blocked in the parliament. There are several activities in Switzerland targeted on livestock production. The organic sector is not specifically addressed. This is why we decided to focus on organic production.

The case studies

In Switzerland, we work on two case studies about organic production: organic pork production; organic veal and beef production. Regarding the organic sector, the use of antibiotics is allowed but restricted. According to Article 24 of the Implementing Rules (Regulation (EC) No 889/2008) of the EU Organic Regulation, diseases must be treated immediately in order to avoid animal suffering; chemical-synthetic allopathic veterinary medicines, including antibiotics, may then be used under strict conditions.

When we talk about organic production, almost all farms in Switzerland are certified according to the label "Knospe" or "Bud" which belongs to the organic farmers association Bio Suisse. This label is based on the EU /Swiss Organic Regulation but the private standard calls for measures beyond this basis. Bio Suisse has always endeavoured to keep the use of antibiotics to a minimum. Animal health is promoted through a reduced performance, access to pasture, adapted feeding, the choice of suitable breeds and breeding methods. Natural remedies and complementary medical methods also have priority. Also, animals slaughtered younger than one year are only allowed to be treated once. In 2017, Bio Suisse implemented a new directive on the use of antibiotics on Bud farms which will apply from 1 January 2017. Critical antibiotics (also called reserve antibiotics) may now only be used under strict conditions. With the new guideline, Bud farmers are sensitised to even more targeted and moderate use of antibiotics.

There are no data about antibiotic use in the Swiss livestock sector. However, experts generally assume, that the use of antibiotics in organic systems is lower compared to the conventional systems. There are nevertheless challenges for the organic sector, which are addressed in the two case studies. In the case study on organic pork production, we work on a further reduction of antibiotics in pig rearing and fattening. In order to meet the requirements of the organic regulation, organic pigs should receive only one treatment. Currently, we do not know if pig breeders and fatteners manage their animals and how often pigs are treated twice. In the case study and the connected Living labs, we try

to develop a system for the traceability of individual pigs from the breeder to the fattener to document the treatments with antibiotics.
The second case study is connected to dairy but focusses on organic beef/veal production. Milk is one of the most essential products for organic farmers. Whereas most of the farmers are aware of cow health and, more specifically, about udder health, they are much less aware of calf health. In the case study, we will work on improving the rearing system for organic calves.

3.2.2 Identification of stakeholders' desired impacts

The FiBL team held several workshops to identify the relevant stakeholders and map them in an interest-impact diagram. The results will be validated in the upcoming living lab. So no validation has been made yet.

For both case studies, the veterinarians were identified as relevant stakeholders. For farmers, veterinarians are a suitable source of information and extension. And they are a governmental authority. Hence farmers have to follow their advice. In Switzerland, veterinarians prescribe and sell AM's directly to farmers, certain AM's can also be sold on stock to farmers (BLV, 2019a). For the latter case, the farmer and the veterinarian sign an agreement called "Tierarzneimittelvereinbarung" (TAM-V), which obliges the veterinarian to check the health status of the animals regularly and the farmer to use the pharmaceutical properly (BLV, 2019b). The profit margin of AM sales constitutes a considerable source of income for veterinarians. According to a study by Pont et al. (2020), veterinarians who support calf and veal fattening farms in Switzerland generate 82% of their profits from pharmaceutical sales. Moreover, the study revealed that 54% of these profits originate from AM sales. The study concludes that under the current system, a reduction of AM use in animal production would seriously decrease income in Switzerland's veterinarian practices. As a consequence of veterinarians selling AM directly to farmers, pharmacies in Switzerland play only a minor role in AM dispensing. Even though pharmacies are allowed to sell AM to farmers, almost all veterinary pharmaceuticals are only available on prescription. Therefore, the share of pharmacies in AM sales in veterinary medicine is negligible (A. Maeschli, personal communication, 8 September).

For both case studies, the organic farmers association is relevant as a market actor and based on their impact on policy-making. The association funds research projects targeted on the needs of organic farmers and makes sure that farmers are involved in developing and executing such studies.
Also relevant is the collaboration between farmers. In the case of organic pork, there is a weak collaboration between pig fatteners and pig breeders, and in the case of organic beef/veal there is no existing collaboration between milk producers and veal/beef producers. Contact between farmers is mediated by an animal trader. Contact between a farmer and his/her traders is often very close and trustful.

In the case study on organic beef/veal, the focus lies on providing targeted extension services to farmers and improving the collaboration between farmers and veterinarians. Next steps will be defined in February 2021.
Connected to the organic pork sector, the list of measures cover improving animal health by training for farmers, training for farmers about organic farming, and systems improving the traceability in the supply chain. These measures were developed on the living labs and are already partly taken up by the organic farmers association.

3.3 The Netherlands

3.3.1 Presentation of the case study

General context

Although knowledge of the negative consequences of extensive antimicrobial use in humans and animals accumulated over the decades, total therapeutic antimicrobial use in farm animals in the Netherlands doubled between 1990 and 2007. A series of facts and events formed a window of opportunity to reduce antimicrobial use in farm animals. The recent discovery of significant reservoirs of antimicrobial-resistant pathogens such as methicillin-resistant Staphylococcus aureus (MRSA) and extended spectrum beta-lactamase-producing bacteria (ESBL) in farm animals, with potential public health implications, combined with an increasing lack of confidence of the public in intensive livestock industries, and discrepancy between the very low antimicrobial use in humans and high use in animals, resulted in intensive collaboration between the government, veterinary professional organizations and important stakeholders within the livestock sector. A combination of compulsory and voluntary actions with clear reduction goals resulted in a 56% reduction in antimicrobial use in farm animals in the Netherlands between 2007 and 2012 and aimed at accomplishing a 70% reduction target in 2015. The 2019 sales data revealed a 69.6% reduction from the government-specified reference year of 2009.

Veterinary Medicines Authority

In response to the need for an independent body to monitor antimicrobial usage at herd level, in 2010, the independent Dutch Veterinary Medicines Authority (SDa) was established as a public–private partnership between the government, the veterinary professional organisation (KNMvD) and livestock industries. The task of the SDa is (i) to collect and report reliable antimicrobial usage and prescription data from all individual farms and veterinarians and (ii) to set annual targets for antimicrobial use in the different major livestock sectors, including species-specific (and categories within species) benchmark indicators that differentiate between moderate, high and very high users (farmers) and prescribers (veterinarians). High users and high prescribers can be subjected to disciplinary sanctions by the private IKB systems (integrated chain control; quality assurance systems) and the KNMvD, respectively. They can also be subjected to additional controls of the Dutch Food and Consumer Product Safety Authority (NVWA) of the Dutch Government (SDa, 2013).

Restricting the Specific Use of Antimicrobials

In August 2011, the Dutch Health Council (HC), an independent scientific advisory body for the government and parliament, presented on request of the Ministers of Health and Agriculture scientifically-based recommendations to prevent further development and spread of antimicrobial-resistant bacteria in animal production (Anonymous, 2011a). Most of these recommendations showed similarities with the advice of the European Food Safety Authority (EFSA) Panel on Biological Hazards also published in 2011 (EFSA, 2011). Particularly, the development and spread of ESBLs were targeted as this was considered as the major resistance problem. There were indications that the use of 3rd and 4th generation cephalosporins in group treatments (e.g. extensive systematic and illegal use in hatcheries) had promoted the occurrence of ESBLs. There are no data about the amount of antimicrobials used in hatcheries. Among the recommendations of the HC were the exclusive use of newly developed antimicrobials for humans, an immediate ban on preventive and systematic therapeutic group treatments

of animals with the as critically important considered 3rd and 4th generation cephalosporins and fluoroquinolones (Collignon et al., 2009), a future ban on the use of colistin and the phasing out of all preventive and systematic veterinary use of β-lactam antibiotics and aminoglycosides in animals. The different existing private IKB systems translated these recommendations into specific regulations that radically restricted the use of 3rd and 4th generation cephalosporins and fluoroquinolones in farm animals. The Veterinary Antimicrobial Policy Working Group (WVAB) of the KNMvD subsequently reclassified veterinary antimicrobials into first, second and third choice for use in the existing veterinary treatment guidelines (formularies) and veterinary practice, based on the recommendations of the HC. The government took the responsibility for enforcement of these private regulations and made proposals to incorporate these private regulations into legislation. Further on, the government banned the preventive use of all antimicrobials in animals (Anonymous, 2011b).

Obligations for Farmers

The private IKB systems introduced in 2009 the prerequisite for farmers to only procure veterinary services and veterinary medicines from one veterinary practice (1-in-1 relationship) to reduce competition between veterinary practices and to ensure a proper knowledge of the farm of the prescribing veterinarian. This measure was already proposed in the MoU in 2008 and was in 2012 imposed for all farmers by the Product Boards for Livestock, Meat and Eggs (PVE; public–private organization with legislative powers for the whole livestock sector) (Beemer et al., 2011). The PVE in 2011 decreed – as mentioned in the MoU – the introduction of the Farm Health Plan (FHP) and Farm Treatment Plan (FTP) and central registration of all prescribed and delivered antimicrobials on farms. These measures were subsequently incorporated in the existing private IKB systems for different livestock sectors. The FHP and FTP must be developed in collaboration between the farmer and the farm veterinarian and evaluated annually. The FHP should contain information about farm-specific risk factors for the introduction and spread of infectious diseases and the specific management measures as proposed by the farmer to control these risk factors and improve the health status of the animals. The FTP is a farm-specific treatment protocol for the most common (infectious) diseases on that farm that can be empirically treated by the farmer. This FTP should be in accordance with the formularies developed by the KNMvD and other relevant farm-specific information like susceptibility patterns of cultured pathogens and historical treatment results. In principle, only first-choice (non-critically important) antimicrobials from the WVAB formularies are allowed in this FTP.

Turkey farms

The 2019 DDDAF[1] distribution for turkey farms is wide and shows many farms with usage levels exceeding the SDa's provisional benchmark threshold and several outliers with usage levels higher than 40 DDDAF (Figure 1). The benchmark threshold for turkey farms has yet to be agreed upon by the turkey farming sector. Usage levels at turkey farms are generally high. The turkey farming sector has initiated a coaching project for turkey farmers and veterinarians. It is the SDa's hope that this will lead to usage level reductions, particularly at those turkey farms currently or persistently recording high DDDAF values. In 2019, 63% of turkey farms exceeded the SDa's provisional benchmark threshold, indicating that more should be done to limit the amounts of antibiotics used at turkey farms. The significant association between recurrent diseases of the gut (such as clostridium and coccidiosis) and the

[1] The defined daily dose animal used to express the amount of antibiotics used at a particular livestock farm. The DDDAF is determined by first calculating the total number of treated kilograms at a particular livestock farm for a specific year, and then dividing this number by the average number of kilograms of animal present at the livestock farm concerned. It represents the amount of antibiotics used at a particular livestock farm, and is used for benchmarking individual livestock farms.

level of antibiotic use indicates that gut health is an important concern in turkey farming. It is recommended that attention be paid to possible causal relationships between gut health, gut diseases, and antibiotic use.

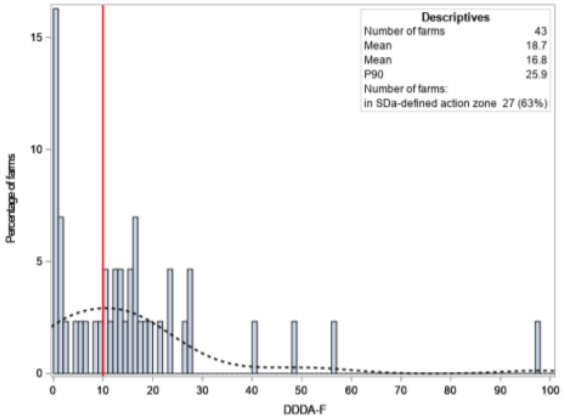

***Figure 1**: DDDAF distribution for turkey farms. The red line represents the SDa's provisional benchmark threshold, which has yet to be agreed upon by the turkey farming sector (SDa report usage of antibiotics in agricultural livestock in 2019)*

Farms with sows and piglets and farms with fattening pigs

Mean antibiotic use at farms with sows and piglets and farms with fattening pigs is low. The 2019 DDDAF distributions for these production categories are characterized by long tails, with some farms recording a multifold of that particular production category's mean DDDAF value (Figure 2). The pig farming sector and the Ministry of Agriculture, Nature and Food Quality have agreed upon the application of transitional benchmark thresholds as part of a phased implementation process with regard to the SDa-defined benchmark threshold.

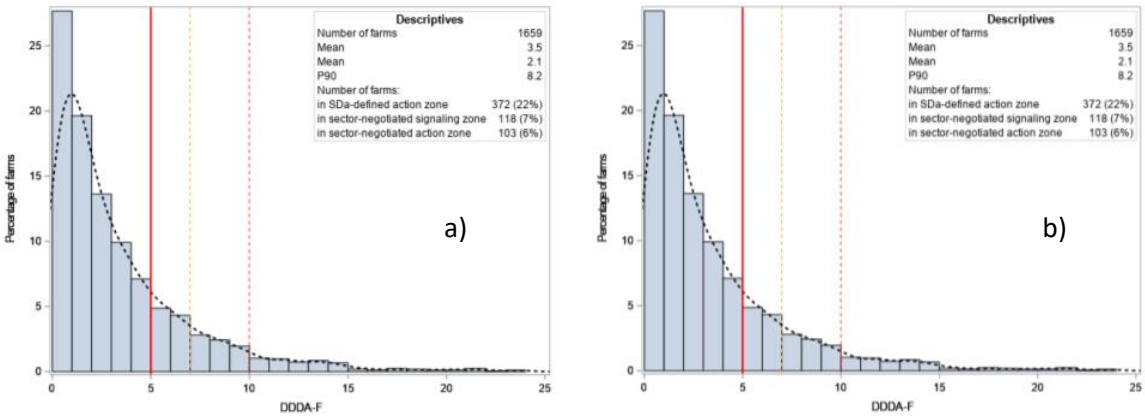

***Figure 2:** DDDAF distribution for farms with sows and piglets (a) and farms with fattening pigs (b). The red solid line represents the SDa's new benchmark threshold. The orange and red dotted lines represent the sector-negociated signalling and action thresholds, respectively (SDa report usage of antibiotics in agricultural livestock in 2019)*

3.3.2 Identification of stakeholders' desired impacts

In Work package 1 we conducted interviews by telephone with different stakeholders and shared the results with the WP1 leader. Nine informants were interviewed of which 2 turkey farmers, 1 farmer and veterinarian, 2 veterinarians, 1 employee of a German turkey integration, 1 person of a Dutch breeder company and 2 experts from Wageningen University and Research center. Interviews were conducted via telephone and lasted about 45 minutes. Data was not transcribed, but summaries were made.

As part of WP6 tasks we made a short online survey for participants to Living Labs (WP3) to gain insight in the desired outcomes. All summaries of results so far can be found in the Annexes:

- Annex 1: Stakeholders'map for the turkey case study in the Netherlands
- Annex 2: Characterisation of stakeholders for the turkey case study in the Netherlands
- Annex 3: Summary of survey desired impacts results for the turkey case study in the Netherlands

3.4 United Kingdom

3.4.1 Presentation of the case study

The case study 'marginal care' focuses on marginal actors, animals and practices in the cattle sector. Marginal refers to those agricultural sectors that have not been the main focus of AMR strategies, and sectors that do not fit within the cultural model of productive, good farming. The case study therefore focuses on calf-rearing: as a farming practice it is often relegated to 'women's work' because of its focus on maternal care and lack of immediate productivity. Calves are therefore not headline subjects in AMR which focus more on mastitis and other problems associated with productive animals. The marginal status of calves also impacts upon their health through poor quality housing, lower labour inputs and financial resources (such as for vaccines). AMR strategies therefore face the challenge of long-standing structural problems, for which many farmers are already aware of.

At present the UK beef, dairy and calf sectors are predominantly small independent producers and present a large number of farms across the UK. This contrasts greatly to the broiler and layer sectors that are primarily large integrated companies. The pig sector is somewhere in between with some integration, some commercial independent farms and the backyard/smallholder keepers. The beef, dairy and calf sectors therefore present a large number of producers with regards to communicating responsible antimicrobial use, policy, collecting data on antimicrobial use and to coordinate efforts to reduce antimicrobial use. The dairy, beef and calf sectors need to be considered together as all are closely linked. For example, male calves are often sold from dairy farms for finishing on other farms. Therefore, dairy farms often have low antimicrobial use in calves on farm but this use may be high when the calf leaves the farm. Many dairy farms also buy in heifer replacements from other dairy farms which are often of an unknown health status.

There are attempts to create integrated dairy to beef supply chains. Companies such as Blade, Buitelaar and Meadow Quality are increasingly influential. They purchase and rear calves, then either finish them for beef or sell them on as replacement heifers/beef cows. Increasingly, they have exploited changing policies/pressure minimizing the slaughter of infant dairy bulls and have worked to integrate the dairy and beef sectors. Larger companies have contracts with farmers specifically to rear or finish calves, and set targets for their growth and protocols for AMU and practices of care. These companies

often encourage and support investment in modern farming technologies/infrastructure seen as beneficial to calf health. However, the nature of their enterprise means calves within these systems may have increased stress levels and require more AMU, especially if early preventative care (e.g. colostrum management) are not managed carefully.

In terms of AMR strategies, the case study is impacted by the main strategies at a national level. RUMA is an independent non-profit group involving organisations that represent all stages of the food chain from 'farm to fork'. This reflects the importance of traceability, transparency and accountability at all stages in the chain: from primary food production, through processing, manufacturing and retailing to the final consumer. Its membership includes organisations representing interests in agriculture, veterinary practice, animal medicines industry, farm assurance, training, retailers, consumers and animal welfare interests. RUMA aims to produce a co-ordinated and integrated approach to best practice in animal medicine use. It has an established communications network with government departments and many non-governmental organisations.

The targets task force (TTF) was first launched in 2017 and is an industry-led initiative to set antimicrobial reduction targets for the key livestock industries. Each livestock sector has a veterinary surgeon and a producer nominated by the industry who advise on the targets. The first round of targets were to reduce antimicrobial use to a certain level by 2020 from baseline figures calculated for 2015. The initial TTF included the beef and dairy sectors. A second version of TTF launched in winter 2019 and included three separate sectors for cattle: beef, dairy and calves. Further reduction targets will be determined by summer 2020 and will undergo a consultation with the wider industries.

The TTF are observed by the following orgnaisations; Agriculture and Horticulture Development Board (AHDB), British Veterinary Association (BVA), Food Standards Agency (FSA), National Office for Animal Health (NOAH), Red Tractor Assurance and the Veterinary Medicines Directorate (VMD).

Red Tractor Assurance is the UK's largest food standards scheme and the only one to cover all areas of food production from animal welfare and food safety to traceability and environmental protection. Red Tractor require dairy farmers to collect and report antimicrobial use as a scheme requirement. Other assurance schemes may make decisions on antimicrobial use for its members. These may be restrictions or regulations. For example, Quality Standard Mark (QSM) for beef and lamb, the Soil Association and Quality Meat Scotland.

Finally, supermarkets play an influential role. These purchase and sell animal products to consumers. As supermarkets are near the end of the supply chain, they have a large influence over many actors and have performative relationships with their consumers by both dictating and responding to demand. Supermarkets often establish relationships with specific suppliers, consultants, producers etc. to ensure the smooth supply of animal products. These might be tied to Assurance schemes which guarantee standards within the chain, and monitor AMU. Supermarkets exert numerous forms of power and are highly influential. Primarily, they have contracts with farmers/processors/suppliers with fixed targets and protocols, and adhere to government regulations, many of which relate to AMU. They offer financial incentives to a variety of stakeholders to enter these contracts, and have penalties for those who do not fulfil their obligations. However, it is only recently that these contracts have begun to incorporate calves. Supermarkets are seen as driving and implementing change in AMU as a reflection of consumer and government demand. However, they have such power that they are often seen as exploiting weaknesses in the supply chain for their own means e.g. farmers' reliance on dairy/beef contracts to survive.

3.4.2 Identification of stakeholders' desired impacts

In work package 1 University of Cardiff conducted 12 online interviews with different stakeholders and the James Hutton Institute conducted 16 interviews, and shared the results with the WP1 leader. Stakeholders were identified by scanning grey literature, pre-existing researcher knowledge and interviews conducted as part of WP2 (see below).
The stakeholders were from the following categories:

STAKEHOLDER	CATEGORY
1	ACADEMIC (VETERINARY SCIENCES)
2	AGRI-CONSULTANT
3	AGRI-TECH ENTREPRENEUR
4	FEED COMPANY REP (YOUNGSTOCK SPECIALIST)
5	DRUG COMPANY REP (VETERINARY ADVISOR)
6	MILK COMPANY REP (FARM ADVISOR)
7	AGRI-TECH ENTREPRENEUR
8	AGRICULTURAL ADVISORY BOARD
9	NUTRITIONAL COMPANY REP (YOUNGSTOCK SPECIALIST)
10	VETERINARY CONSULTANT
11	AGRI-CONSULTANT/ FARMER SUPPORT GROUP FOUNDER
12	VET
13	FARMER ORGANISATION EMPLOYEE
14	GOVERNMENT EMPLOYEE

The following graph (Figure 3) was generated from 12 interviews carried out by Cardiff with key stakeholders. It is based upon *their* understanding of how different stakeholders impact AMU and their importance to calf-rearing at the farm-level.

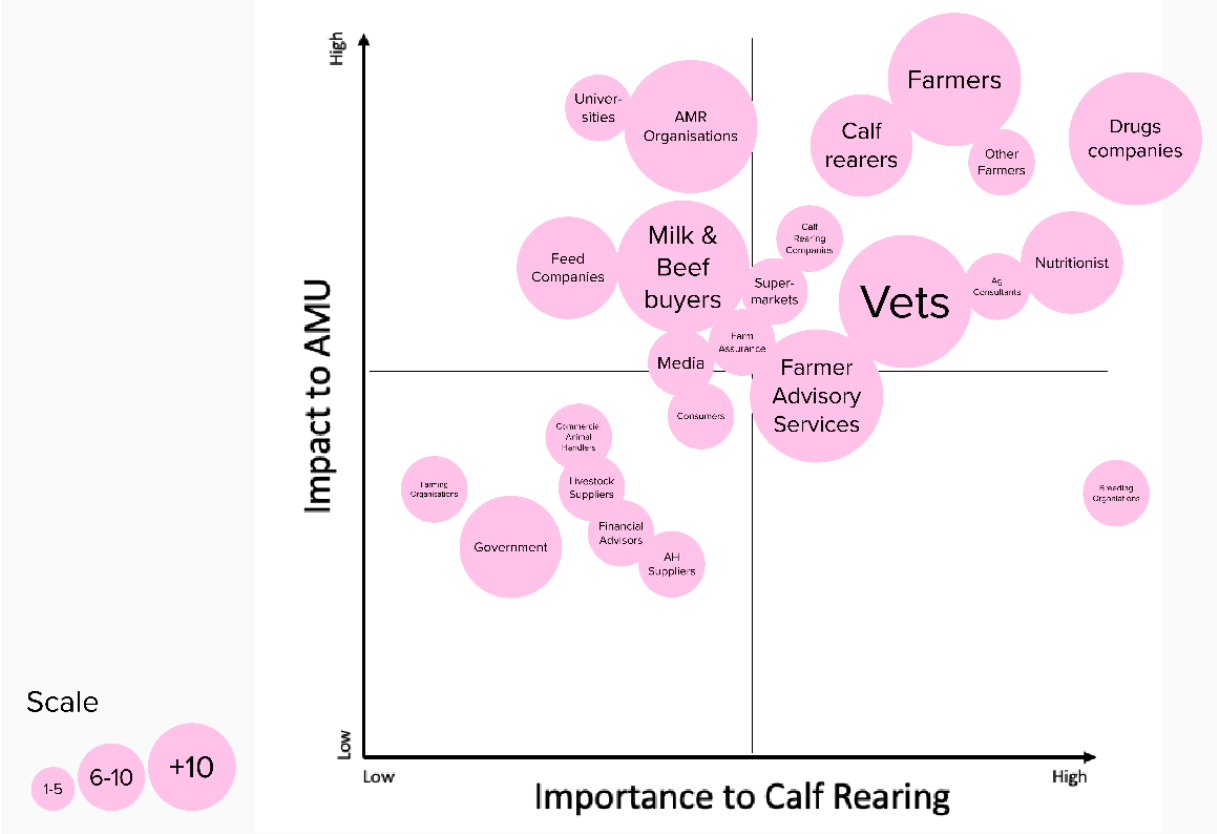

Figure 3: *The importance of key stakeholders on calf-rearing and their impact on AMU*

In relation to desired impacts, stakeholders judged calf-rearers to have a high interest in AMU as anti-microbials are seen as a critical part of animal health care. However, decisions about their usage are often made in relation to the long and short-term costs of intervention vs non-intervention. Most farmers have close relationships with their animals, so the costs/benefits of AMU are emotional/affective as well as financial. Calf-rearers are generally understood to prioritise the health and welfare of their animals, though this does not translate to having a powerful voice. Though calf-rearing is usually a (lowly) paid job, calf-rearers' interest is frequently non-financial as they tend to be motivated by good animal care. However, this is closely coupled to the financial interests of the farmer, who will have the final say on AMU.

The interviews also revealed perceptions of the desired impacts amongst other stakeholders. For example, calf-rearing companies prioritise the movement and mobility of calves between farms and rearing units. These movements are shaped by factors such as disease outbreaks and the associated need to reduce stocking densitities to minimize exposure risks, and private regulations that set conditions on how and when calves can be managed. For these companies, the desired impacts are to maintain these circulations and mobilities of calves since their business depends upon them. Reductions in AMU may threaten this model and introduce greater variability and cost to the management of calves. Similarly, veterinary practitioners are seen as highly influential in overseeing animal health practices on farms, prescribing and distributing antimicrobials to farmers, and treating animals on a routine or emergency basis. However, their relationship with drug companies and need to sell pharmaceuticals to raise money can be a cause of concern. For veterinarians, maintaining both their income and their trust/legitimacy in the eyes of farmers are crucial to reforms to AMU.

For WP2, 27 interviews were conducted with calf-rearers. Interviews were conducted online and lasted an average of 100 minutes. Initial analysis of these interviews reveals:

- Firstly, calf rearing is performed in a variety of different farming systems and which fit into different parts of the supply chain – this means that there is a lot of diversity when it comes to AMU. Farms themselves are diverse and calf-rearing on farm is carried out in various ways and performs different functions. Eg some farms rearing calves as singular calf rearing enterprises and others that are rearing for replacements in their dairy herd. Within these different systems and different farming contexts animal health (in calf-rearing) and practices of AMU vary considerably and are embedded in a variety of different socio-economic contexts which poses a challenge to 'one-size fits all' AMU policy.
- Secondly, people involved in calf-rearing become calf-rearers through a variety of different pathways that inform their understanding of calf-health and the ways in which it can be managed under their care and their perception of the use of AMs.
- Thirdly, calf-rearing is restrained by the farm environment and infrastructure (eg buildings and housing) and the ability of farm-decision makers to invest in improvements or adapting existing infrastructure in ways which can minimise or reduce poor animal health and consequentially the need to resort to use antibiotics. However, the skills and knowledges and techniques that calf-rearers acquire through the experience of raising calves perform an important role in preventive health which is sometimes overlooked and can go a long way to prudent antimicrobial usage beyond narratives that suggest a huge cultural change is required. Relatedly, calf-rearers associate good calf-care with anti-microbials – they are a crucial part of the care 'armourary' – but calf-rearers recognise the need to adapt their use to fit individual rather than general circumstances. In this way, calf-rearers demonstrate a form of sensemaking: their aim is to care for calves in the best way possible in an uncertain and changing environment. Antimicrobials are part of the solutions they develop, alongside others, but the choices they take reflect the environments they are situated in, the challenges of learning in a dynamic situation, but equally the inertia of cultural and economic farming contexts.

4 Long ex-ante impact assessment case-studies

4.1 Belgium

4.1.1 Presentation of the case study

General context of AMU in Belgium

For the past 10 years, Belgium made big efforts to reduce antimicrobial use in livestock production.

BelVet-Sac database
The BelVet-Sac database was created to assure the yearly collection and analysis of sales data of antimicrobials for veterinary use when the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project that was launched in 2010. A report is published yearly here.

AMCRA

Several actors of the Belgian animal health system such as representatives of farmers' and veterinarians' unions, academia and feed and pharmaceutical associations created the Centre of Expertise on Antimicrobial Consumption and Resistance in Animals (AMCRA), with the aim to reduce antibiotic use in animals through advice, guidelines and awareness raising among veterinarians, farmers and the general public.

In 2014, AMCRA drew up a strategic plan (AMCRA Vision 2020 only in FR/NL) consisting of:

- 3 key objectives
  - 50% reduction in AMU by 2020 (40,9 % in AMU was registered in 2019)
  - 75% reduction in the use of the most critically important antibiotics by 2020 (Achieved, ca. 77.3% reduction in 2019)
  - 50% reduction in the use of antibiotic-medicated feedingstuffs by 2017 (Achieved, 71.1% reduction in 2019)
- 7 operational objectives

This resulted in a covenant, clarifying the division of tasks in the context of the commitments to be made to achieve the objectives of the strategic plan, signed by AMCRA, the Ministers for Health and for Agriculture, and various partners involved in AMU in veterinary medicine.

In 2020, a new strategic plan (AMCRA Vision 2024) was drawn with:

- 4 key objectives
  - 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
- 9 Action points

Sanitel-Med

Sanitel-Med was launched in 2017 by the Federal Agency for Medicine and Health Products (FAMHP) in order to collect AMU-data at species level. Currently, it is compulsory for poultry (laying hens and broilers), pigs and veal calves producers to have all antibiotics administered or dispensed registered by the company veterinarian (Royal Decree of 31/01/2017). Both the animal farmer and the company veterinarian receive reports benchmarking their AMU.

Despite the efforts of the livestock production sector, Belgium still has a substantial AMU compared to other EU countries (ca. 130 mg/PCU (2017) and 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.

Flemish pig sector

The Flemish pig sector also took initiatives to reduce the use of antibiotics. In 2000, the non-profit organization Belpork was created with the aim to promote the quality of Belgian pig meat in a sustainable way. The organization managed the Certus quality label that guarantees strict standards, controls and traceability. In 2014, Belpork lauched the **ABregister** and all producers approved within the Certus quality label, which then represented ca. 50% of the Flemish pig farms (and ca. 70% in 2019) and covered 24% of the annual slaughters, were required to have all antibiotics administered or dispensed registered by the providers of the products. Belpork collaborated with AMCRA's scientific department for the analysis of the AMU-data and Certus-producers received a bi-annual benchmarking report that

compared the farm's BD_{100}, or the number of days of antibiotic treatment over 100 days, to two BD_{100} limit values (the 50th and 90th percentiles of the frequency distributions) to define if the producer was a low, a more than average or a large antibiotic user. Later on, the quality system for poultry farmers, Belplume, and the quality label for Flemish dairy farms, IKM Flanders, also joined the AB Register, obliging their participants to register the use of antibiotics. These databases have now been coupled to the national database **Sanitel-Med** and AMCRA is still in charge of the benchmarking reports.
In 2019, fatteners and weaned piglets were the animal categories with the largest mass of antimicrobials used (68% of tonnes used) in Belgium, as described in the latest BelVetSAC report.

Flemish veal valves

The Belgian veal calf sector is a highly integrated production. Since 1996, nearly the entire production is controlled according to the very strict Charge Book of the non-profit **organisation 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 registered and AMCRA is in charge of the benchmarking reports. In 2019, the sector reduced its AMU by 21% compared to 2018, probably as a result of the "10 steps action plan" the sector has adopted. Despite its tremendous efforts, veal calf farms have the highest basic level of antimicrobial use and a BD_{100}-species (the amount of treatment days out of 100 days based on the total amount of antimicrobials used per species and the total mass animals at risk per species) of 22,27, which is 3,3 times higher than pigs (6,72) and 4,15 times higher than poultry (5,32), as described in the 2019 BelVetSAC report.

4.1.2 Identification of stakeholders' desired impacts

For both case studies, all the relevant stakeholders, their roles and interactions have been identified in the context of task 1.4. based on 10 key-informant interviews and the analysis of an additional 7 key-informant interviews which were done in a previous project. The preliminary results of the stakeholder mapping were discussed with the participants of the kick off meeting of the Belgian Living Lab (9th of October 2020, with about 50 participants) and the feedback was used to finalise the stakeholders map of the Flemish pig sector as well as to complete the one of the veal calves case study.

Data on stakeholders' behaviour, practices, knowledge and motivations is currently being reviewed based on existing publications. Due to Covid-19, WP2 in which farmers and veterinarians will be interviewed has not started yet, so detailed data and analysis regarding these stakeholders is currently lacking. Further, also WP1 has experienced delays because of Covid-19, so there is also limited input from that WP1, which could be used for identifying stakeholders' behaviours, practices, knowledge and motivations. Based on a review of a limited number of previous studies in these sectors in Belgium, a number of conclusions can be formulated. However, it must be taken into account that there is a rapid evolutions and that not all previous studies were very recent.

- Antimicrobial consumption in Belgium is highest in the pig sector (Fillippitzi et al., 2014), with the main reasons for its use being digestive disorders and streptococcal infections in piglets, as well as respiratory problems during the second half of the battery period (Callens et al., 2012).
- Pig farmers in Belgium often perceive their own antimicrobial usage as being lower than their peers in the same country, and lower than or comparable to similar farmers in other countries. Further, pig farmers in Belgium showed little concern over antimicrobial usage and antimicrobial resistance (Visschers et al., 2015).

- Veterinarians in Flanders (main pork production region in Belgium), indicated that suboptimal climate conditions, poor biosecurity and farmers mentality were among the main reasons for high antimicrobial use in pig production (Postma et al., 2016).
- Veterinarians are more optimistic about possibilities for reducing AMU than farmers, and farmers intentions to reduce AMU were mainly associated with the feasibility of reducing AMU (Visschers et al., 2016a).
- Farmers reported AMU is associated with their perceived risks related to AMR. However, in general they perceive many benefits from using AM and only few risks (Visschers et al., 2016b).
- A systemic analysis of antimicrobial use in pig production revealed several systemic obstacles such as the provision of 'free' advice by feed mills and the fact that the business model of veterinarian was largely focused on the sales of antimicrobials (Rojo Gimeno et al., 2018).

The stakeholders' AM-related impacts they wish to contribute to through the ROADMAP project will be defined in the coming living labs planned in February and March 2021. This is further explained in the next paragraph.

4.1.3 Ex ante impact assessment

When considering the ex ante impact assessment method, the first step was to define and fine-tune the narrative. For this, we used AMCRA's vision 2024 for the initial diagnosis and impact hypothesis as it justifies the intervention and describes the national expectations of impact for livestockthrough 4 key objectives and 9 action points.

On 9 October 2020, a first joint online meeting (+-1h30) was organized for the two case studies and problems of the Flemish animal health system were discussed. These problems were divided in 4 categories: production/technical, social, economic and regulatory difficulties. These problems were further discussed during the first living labs of our case studies (9/12 for the veal calves and 15/12 for the pig sector, +-1h30 each). In these living labs, problem trees were also drawn and further completed during the second round of living labs that took place on 26 January 2021.

Information gathered during the joint and first two living labs was used to create an exhaustive list of production/technical, social, economic and regulatory difficulties for each case study. This will later be linked to past, current and planned initiatives to obtain an overview of current problems and already available or developed solutions.

During the upcoming living labs (25/02/2021 and 30/03/2021), the problem trees will be finalised and an overview of past and present initiatives will be discussed with the participants. The aim is to allow participants define the problems (or tree branch) they wish to address in the context of the living lab and how they will do so in order to contribute to the objectives set by AMCRA's vision 2024.

4.2 Denmark

4.2.1 Presentation of the case study

Pig case studies – Conventional and conventional label production

In Denmark, AMU in livestock is primarily driven by pigs. 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, an early report on the AB usage in animal and humans in Denmark, the frequency with which pigs are treated with AB has decreased by 30% over the past decade. Thus, on a given day in 2019, a total of 2.3% of all Danish pigs received some sort of antimicrobial treatment. The figure for 2010 was 3.3% [Anonymous, 2020]. Compared to other countries with similar industrialized pig production, the usage of AB in Denmark is low. Usage of AB is strictly monitored by the national authorities via the database Vetstat (which is publicly accessible). All use of AB for livestock is by a veterinary receipt. If farmers use AB in amount above-set thresholds (Yellow card limits which are gradually decreased over the years) they can be underlain certain restrictions.

As in other countries, weaners is the age group receiving the majority of antibiotics in pig farms. Diarrhoea (68% of doses), leg- and central nervous system-related disease (21% of doses) and respiratory disease (10% of doses) are the main reasons for treatment with AB in Danish weaners.

In 2017, based on a request from the American market, Danish Crown (the largest abattoir in Denmark) started recruiting farmers for production of so-called “Pure Pork” or “Pigs raised without antibiotics” or OUA pigs. These farmers would all be conventional farmers that were interested in producing within a label where they were offered a premium price for pigs that they could guarantee had never in their life been treated with AB. In practice, this is done through earmarking at the birth of all pigs that seem strong enough to grow up without treatment. If treatment is given at any point, the earmark is removed and the pig is sold as a non-Pure Pork pig. There are no rules about the housing of Pure Pork pigs separated from pigs that have received AB. Scientifically, it has not been documented that this type of production creates less resistance than “traditional” raising where AB is sometimes used for whole batches. This seems to be due to the fact that resistance spreads in pens – even if just a proportion of the pigs within this pen are treated. Today, around 50 farmers produce within this label. They have learned some lessons on how to reduce the level of medication. For example, many of them wean at 5 rather than at 4 weeks of age and they generally use quite many vaccines and improved standards for feeding. These management tools do not come for free – and therefore farmers need the premium price. More farmers stand in line to join the label. Many of them already have low consumption of AB and would like to get the extra payment for this achievement.

Unfortunately, sales have not been as expected or hoped for in the beginning. This counts for both the Danish and the American market. One of the problems is that not all cuttings from the pigs can be sold with a premium price – this primarily counts for the more expensive cuttings. Another problem seems to be that some consumers cannot see why they should pay more for this label product.

The case study on organic dairy cows and calves

The Danish case study focuses on organic dairy herds, and takes the concrete starting point in a small dairy company, Thise (https://thise.dk/en/), and follows a storyline which started in 2003 where they decided to start a process of ‘phasing out antibiotics’, till 2022 (where the ROADMAP case study ends). The case study will follow stable schools (a special way of running farmer groups), and a market-driven approach to reducing antibiotics among dairy producers who are shareholders in the same company. Data will be focusing broadly on the Danish dairy sector, and more detailed data will be analysed from Thise dairy company. However, the case study will involve other organic producers 2021-2022 (Naturmælk and Arla Foods). Furthermore, since the Living Lab comprises both organic and conventional dairy cows and calves, the case study will analyse parallel lines and initiatives throughout the dairy sector, based on qualitative data.

4.2.2 Identification of stakeholders' desired impacts

Pig case studies – Conventional and conventional label production

Stakeholders from the whole production chain are represented on Figure 4 and described hereafter.

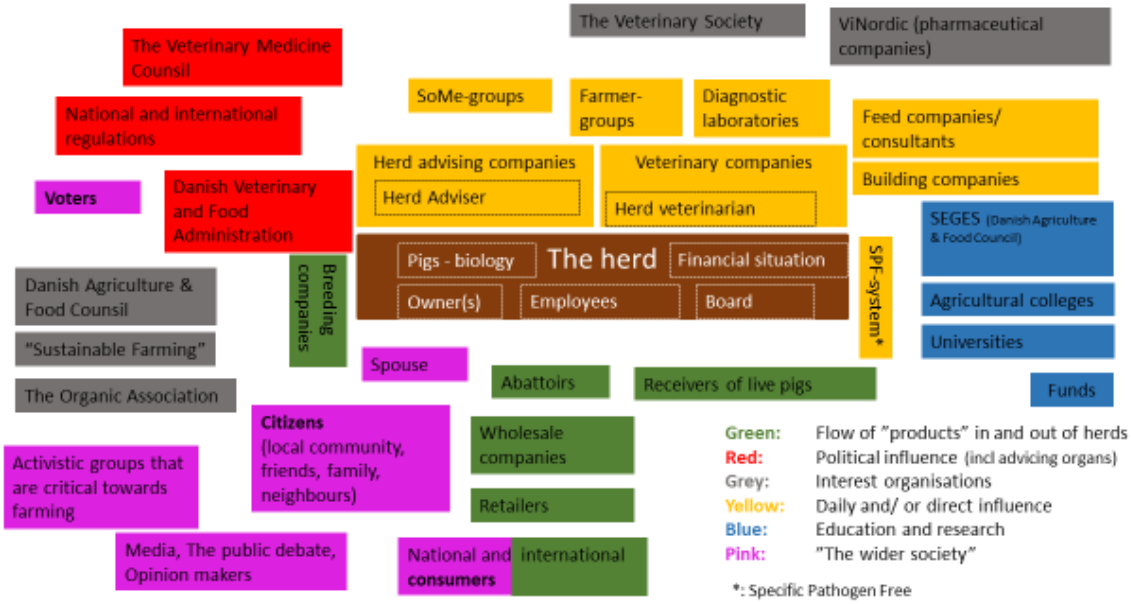

***Figure 4**: Stakeholders' map for pig production in Denmark*

Farmers producing Pure Pork: Farmers engage in OUA label production for two main reasons: The premium price and the professional challenge. The majority already had low consumption of AB before joining the label, but since they had not focused on the number of pigs they were able to raise without AB they were not sure how it would turn out. Today, many of them produce around 70% of their pigs without AB. They desire to keep a premium price for these label pigs – the premium has decreased over time due to problems with selling the meat. It is questionable whether these farmers would like more farmers to join the label. As it looks now – they wouldn't because then the premium would probably be reduced again. The professional challenge in producing Pure Pork is valuable and affects the way farmers feel pride in their work. It would be of no advantage to these farmers if the general consumption of AB in Danish pig production was reduced – because it would be more difficult to differentiate and thereby earn a premium.

Farmers producing "traditional" conventional pigs: These farmers are of course different and have different motivations. From a general point of view, however, there is no reason for these farmers to aim for a lower consumption of AB (as long as it stays below the Yellow Card limit and stays as cheap). Vaccines and other measures to reduce the need for AB are always more expensive and more complicated to integrate. From a broader perspective (probably also – at least in the long run – from a marketing point of view) it seems to be an advantage for Danish farmers that they are known abroad for having a low consumption of AB's.
When discussing possibilities for reducing the use of AB, farmers are generally concerned that it will compromise welfare in terms of avoiding to treat sick animals. Farmers see themselves as people who produce what consumers want (to pay for). Most of them have always worked in large industrialized

conventional systems, and have been supported by colleagues, advisors, veterinarianss and industry partners in their understanding of efficient and profitable pig production, so they have not been aiming at changing things fundamentally.

Practising vets: Veterinarians in Denmark do not earn money on medicine, as it is forbidden. They do regular (approximately monthly) visits in herds for advice – as part of the national legislation. At these visits, they prescribe medicine which is then delivered by the pharmacy. Farmers and practising veterinarians are generally concerned about the welfare of pigs when discussing a future with less AB-use in animals. Some of them see problems in the way the Yellow card system functions – because they think it makes some farmers use too little, and thereby compromise welfare.

Farming consultancies: Their role is more or less the same as the veterinarians' – except that they do not prescribe medicine and their advice for farmers is not enforced by law. They are also concerned about compromising welfare if the usage of AB is restricted even more. As for veterinarians, some seem to think that Denmark has reached the limit for reduction.

Seges (Research and Development within the industry): Seges is a part of Danish Agriculture and Food Council – a farmers' organisation. Seges aims to prepare Danish farming for the future and therefore has an interest in holding on to License to produce and constantly reducing the usage of AB. Welfare concerns are the same as described for veterinarians and consultants and farmers. Being a farmers' organisation, Seges is generally working to protect and defend farmers' rights and immediate interests.

Danish Crown – Abattoir: Danish Crown started up the label production of Pure Pork by request from the United States of America. The vast majority of pigs slaughtered at Danish Crown, however, are standard pigs. Most of all, Danish Crown desires to keep their customers (farmers and retailers) and keep their customers happy. Therefore, it is difficult for them to promote a specialized type of label as farmers producing standard pigs could be offended. From a broad perspective, Danish Crown probably gains from selling meat from a country with such a good reputation concerning food safety and with low consumption of AB. It is not straightforward, that they would benefit from Denmark having a lower AB usage. Pure Pork, as it is now, does not seem to be a financial success – because of the relatively low demand from customers and because much of the carcass has to be sold as traditional meat.

Danish Agriculture & Food Council (focus on the export of meat): Everything that could increase consumers' interest in Danish pig meat is a benefit. This includes a high focus on food safety and low use of AB.

Consumers (represented by a professor in consumer behaviour): Consumers have many different agendas when buying meat. Animal welfare is a high priority (when asked – not necessarily when buying). Danish consumers generally – though not all - seem to trust that AB residues are not an issue in Danish meat. The fact that Pure Pork does not sell well might indicate that consumers are not concerned about the use of AB in animals. However, some surveys indicate that low usage of AB is a high priority when consuming meat.

The Living Lab with focus on dairy cows and calves

The case study is focused on organic dairy production, but the Living Lab covers both organic and conventional dairy cows and calves. The stakeholders involved in the Living Lab are presented on Figure 5 and shortly described in the following.

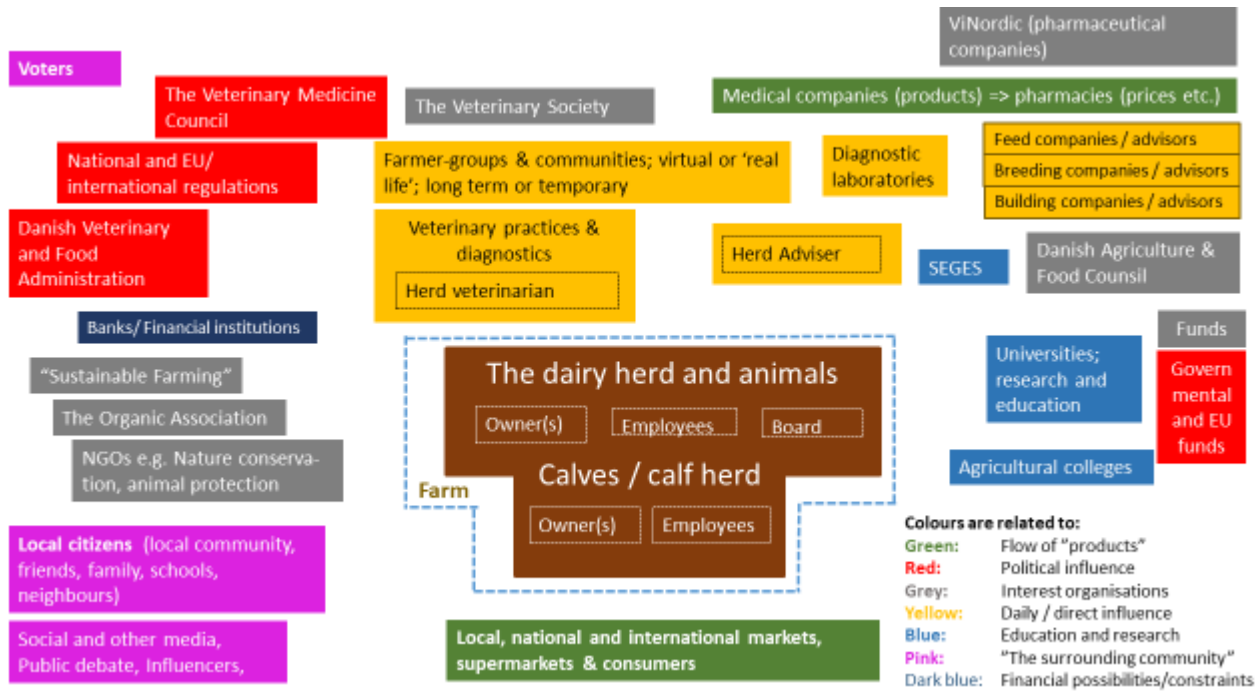

***Figure 5**: Stakeholders' map for dairy cattle and calf production in Denmark*

Private practising vets and veterinary companies (LVK): Veterinarians in Denmark do not earn money on medicine, as it is prohibited. Their role is more or less the same, and most veterinary practices have several owners and employees nowadays. They are engaged closely in herds and with farmers, doing acute treatments on single animals, prescribe medicine (delivered by the pharmacy, which earns money on it), and run advisory service in many different ways. Denmark has "obligatory animal health advisory service", which means that the veterinarian will visit the herd weekly, biweekly or monthly, depending on the number of animals and the construction of the agreement with the farmer, but all as part of the national legislation. They are generally concerned about compromising welfare if AB usage will be restricted by law. For some decades, there seemed to be a mismatch between organic farmers and veterinarians, and studies described that organic farmers asked for advice and guidance on "more natural systems", and (in the 1990s) alternative treatments. The veterinarians were not capable of meeting these requests, but studies described how many veterinarians regarded farmers as reluctant to intervene with medical treatments, and emphasised in public articles that this could lead to risk of lower animal welfare.

The Danish Veterinarian Society, section for production animals: the Danish Veterinarian Society is the umbrella organisation for veterinarians and involved in negotiations on implementation and enforcement of legislation, national as well as international.

Seges (Research and Development within the sector): Seges is a part of Danish Agriculture and Food Council – a farmers' organisation. Seges aims to prepare Danish farming for the future and therefore has multiple interests in farming, and are supporting both conventional and organic dairy farming. They are policymakers, influencing national and international policy-making, participate in national and international research and development projects, and are central in advisory services. As a farmers' organisation, Seges is generally working to protect and defend farmers' rights and immediate interests.

Three different companies: **Himmerlandskød – Meat retailer / Abattoir company** is well-known for producing high-quality and organic meat from Danish animals, which have lived under good animal welfare conditions, and transported only over short distances; **Arlafoods**: a major trans-national dairy company with sales and processing units in several countries, which covers both organic and conventional milk production, and which has several quality programs; and **Calvex**: a company deeply involved in calf equipment and advisory services. All these companies have an interest in contributing to healthy animals and a high and good image of Danish farming and their own role in maintaining a high standard.

Universities educating veterinarians and agricultural advisors: Two lecturers at Copenhagen University involved in teaching Danish cattle specialised veterinarians, and currently involved in research projects on antimicrobial use, are involved.

4.2.3 Ex ante impact assessment

The Danish team was trained in the ImpresS ex ante approach while preparing the first LLs on cattle and pig, respectively. In the case of the Danish LLs, it was initially planned to come with a vision of the future and a central problem previously defined by the research team because of time constraints. The issue of the time allocation to each step at the first LLs was carefully considered. The more time spent on each step, the more everybody is part of a participatory approach and the more we guarantee the success of an intervention based on a shared reflection. Finally, it was preferred to take the time during these first Living Labs to allow the participants to formulate themselves the vision of the future to release voices and to merge the group around a common objective from the first meeting.

Preparation before the first Living Lab

Before the first Living Lab, all participants were interviewed personally by one of the organisers about their approach to the use of antibiotics. The participants in the cattle LL were all interviewed concerning the stakeholders' mapping over a longer period from June-October 2020. The stakeholder map was introduced to the participants to lead their attention to the understanding that they each have a role in a bigger context. For the pig LL, one of the organisers had a 30 minutes phone call with all participants to explain why they were invited (individual reasons), to answer questions raised from the invitation and to know if they could agree on the central issue of the problem tree: "It is difficult to sell pork produced without the use of antibiotics". Some of the participants were already interviewed to complete the pig-stakeholder-map.

Participants were selected for the cattle LL based on inspiration from the stakeholders' map which has been developed through interviews with fifteen stakeholders over three months. In the cattle LL, the participants were selected to cover the sector on both dairy cattle and calves. Altogether twelve participants and nine were able to show up at the first meeting.

For pigs, the stakeholders' mapping inspired to start with the focus on the market situation concerning pig meat produced without antibiotics. Altogether, eleven persons were invited for the first LL. Eight were able to show up (two were hindered by Covid-19 and one for another reason).

For both Living Labs, all the participants talked and the discussions were fluent. The exchanges were lively and respectful. Living Labs have been introduced as a forum of a dialogue where everyone could

learn from each other rather than a forum for discussion where one opinion is worth more than another.

A leaflet including the agenda, presentation of ROADMAP and its overall aim, an explanation of Living Labs, an introduction to the exercise about the translation of the word "prudent" and not the least a presentation of all participants with a picture of each and their written answers to the questions: 1. Few sentences about yourself, 2. Why did you agree to be a part of Living Lab? 3. Which outcome do you expect from participating in Living Lab?; was given to all participants at the first Living Lab meeting. The main purpose of this was to produce an introduction to everybody 'in their own words', to take with the participants home, and secondly to prepare everybody's mind for the upcoming meeting. Every participant was carefully selected, and the organisers perceived it as important that this was emphasized.

Course of the Living Laboratory

The meeting was held in an auditorium with plenty of space to deal with the Covid-19 situation. To encourage as much awareness as possible, it was decided to use only the spoken words, flip overs and post-it notes, and no PowerPoint presentations nor personal laptops. The participants were placed on chairs without tables in a half-circle facing each other, the chair of the meeting and the facilitator. From this location, the meeting until the start of the problem tree was conducted. For elaboration at the problem tree, the participants were moved to another part of the auditorium, with chairs and tables again situated in a half-circle facing a preconstructed wall with large flip overs. Post-its and pens were allocated to each participant.

As a preliminary step, during the dairy Living Lab, participants were asked to express what the English term "prudent" means for them and to translate it into Danish terms. This exercise was not reproduced during the pig Living Lab because of time constraints.

For the first step of ex ante impact assessment, the desirable future and desirable impacts were investigated and identified using *"the flower tool"* in both the cattle and pigs LLs. We focused on the nearby future, which was 'at the completion of the Living Lab' two years ahead, but realised afterwards that we also need to ask participants for a more distant future vision.

The second step was to define the central problem which is the reason why the previously formulated vision is not reached yet. Then, the underpinning problems of this central issue are identified and the causal relationships are represented in a problem tree. It is important to have a global vision of the causal problems in order to work on the delimitation and a more precise definition of what the intervention will specifically address.
Participants from the dairy Living Lab were asked to define the central issue. Then, each participant was first asked to write down on a post-it note the main cause of the problem. Then, the team planned to ask at least 3 times "why" to develop the "roots" of the tree for each of these first level problems.
For the pig Living Lab, a general central issue was already predefined. In phone calls with all participants before the 1st pig living lab, all agreed to this general central issue. While starting the problem tree process, the participants completed the sentence. Each participant also gave a first causal problem. Some of them have been grouped. Then it was decided to develop one branch of the problem tree.

At this stage of the process, the problem trees of both Danish Living Labs need to be completed and the stakeholders mapping validated. This will be achieved during the coming Living Labs and the next step of ex ante impact assessment - mapping of outcomes- will be done during later Living Labs.

4.3 France

4.3.1 Presentation of the case study

General context

National overview on AMU in France is provided yearly by the National Veterinary Medicines Agency (Anses-ANMV), which is in charge of analysing sales data on antimicrobial veterinary medicinal products. In 2019, the total sales volume for antimicrobials amounted to 422 tonnes. This was the lowest tonnage recorded since monitoring began in 1999 (1311 tonnes).
An important decrease in AMU was observed after the first EcoAntibio plan was launched in November 2011. This plan, conducted over the period 2012-2016, comprised 40 actions with a 25% reduction target over five years for the exposure of animals to antibiotics. The main objective of the first plan was met, with a 36.5% decrease in animal exposure to antibiotics during this five-year period. Regarding volumes, in 2018 a 48.2% reduction was observed compared to 2011, the reference year for the first EcoAntibio plan.
The law on the future of agriculture, food and forestry (LAAAF of 13th October 2014) added a new target, focusing on a reduction of 25% over three years (2014-2016) in the exposure of animals to critically important antibiotics, i.e. new generation fluoroquinolones and cephalosporins. This objective was achieved and even greatly exceeded in 2016.
The next plan (EcoAntibio2, 2017-2021) focuses more than the first version on incentivisation rather than regulatory measures. Communication and training play a major role, as do useful alternatives to antibiotics, improvements in preventive measures for infectious diseases and provision of the best tools for diagnosis, monitoring sales of antibiotics and tracking resistance to them.
After a sharp fall in exposure (based on the "ALEA") since 2011, a relative stabilisation of animal exposure has been observed over the last three years for the majority of antibiotic families, with the exception of tetracyclines and polypeptides.

Particularity of AMU, AM legislation, main health constraints in pigs and poultry (broilers)

Regulation
In addition to national actions tackling all livestock species, specific points should be mentioned for pigs and poultry :
- the use of cephalosporins is not authorised in poultry.
- In 2011, the French pig farmers' representative bodies, together with the French swine veterinary practitioners' associations, voluntarily implemented a consensus decision to limit prescription and usage of all third- and fourth generation cephalosporins. This voluntary decision reserved the prescription of such antimicrobials to emergency cases, where the health of the animals was otherwise compromised and no alternate solution was at hand.
- Some of the actions of the EcoAntibio2 plan make a specific focus on pigs and poultry:
    - Action 12: To reduce exposure to colistin by 50% over 5 years on cattle, pig and poultry farms (indicator: ALEA, year of reference: average ALEA for 2014/2015).

- Action 14: Observation of a downward trend for all AMR markers and, specifically, a reduction of 50% over 5 years in E. Coli ESBL in poultry samples (broilers) at distribution stage.

Overview of AMU in pigs and poultry

The tonnage of antibiotics has declined considerably since 1999. In 2018, it was 53.0% and 57.3% % lower than in 2011 for pigs and poultry, respectively. Between 2011 and 2018, exposure fell by 44.9% for pigs and 54.8% for poultry.

The pattern of molecules used and the associated changes differ between species. According to the ALEA per class in 2018, pigs are treated mostly with tetracyclines, penicillins, polymyxins, and then with macrolides, sulfonamides and trimethoprim. Poultry are treated mostly with polymyxins, tetracyclines and penicillins, and then with sulfonamides and trimethoprim.

It is worth noting that, by 2018, exposure to colistin had fallen by 63.2% for pigs and 49.1% for poultry, compared to the average exposure calculated for 2014 and 2015. The objective set by the EcoAntibio 2017- 2021 plan to reduce exposure by 50% has therefore been achieved for the pig sector and is on track to be met for the poultry sectors.

Health issues and challenges associated with antibiotic treatment

Antibiotic treatments are not homogenously distributed over production stages and animal ages. Previous reports showed that, in French pig production, weaned piglets account for a majority of AM treatments and exposure (Sjölund et al. 2016, Hemonic et al. 2018). A study monitoring antimicrobial usage by weight group in 23 farrow-to-finish farms in western France between 2010 and 2016 highlighted at a weight-group level a significant reduction for weaned piglets, then for suckling piglets, sows and fattening pigs. Digestive disorders have been identified as the dominant cause of postweaning treatments (Hemonic et al. 2018). In a study concerning pig farmers' antimicrobial use, digestive disorders in post-weaned piglets was cited first, then arthritis for suckling piglets, lameness for sows and at a lower level respiratory disorders for finishing pigs (Leblanc-Maridor, 2019).

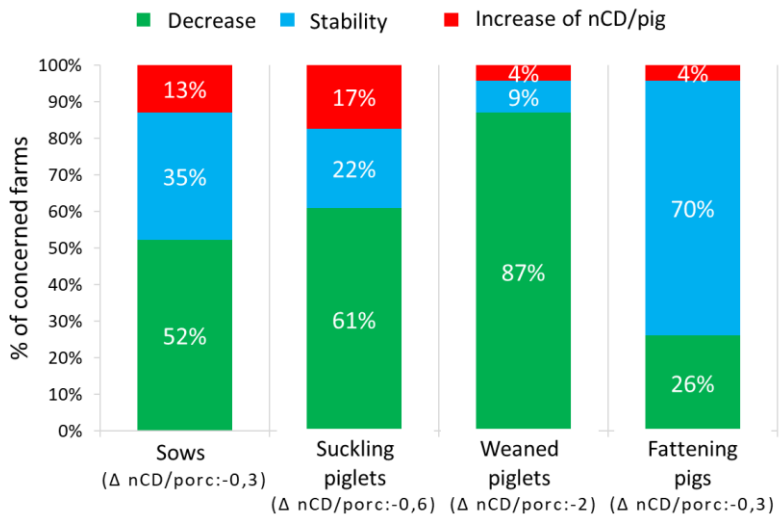

***Figure 6**: Evolution of antimicrobial use by weight-group in 23 farrow-to-finish farms from western France between 2010 and 2016 [M. Leblanc-Maridor, unpublished data]*

In broiler chickens, two critical age periods have been identified regarding antibiotic treatments: (i) 0-5 days (early mortality), (ii) 20-30 days (digestive and locomotor problems).

Pigs and poultry are treated primarily by the oral route. Medicated premixes are used less and less: the ALEA for this pharmaceutical form has decreased by 74.4% and 68.5% % since 2011 for pigs and poultry, respectively (Figure 7).

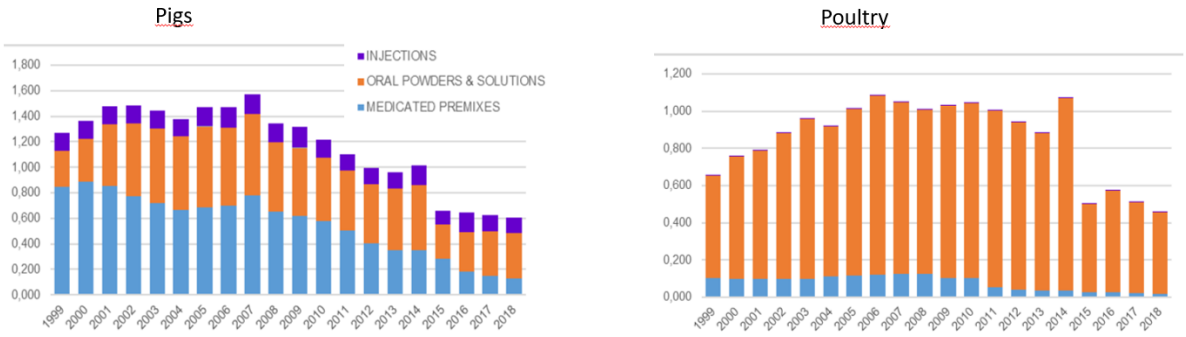

Figure 7: *Change in exposure of pigs and poultry by pharmaceutical forms since 1999 [ANSES-ANMV]*

The optimization of collective treatments, which represent the only possibility for oral treatments, is specially challenging. While it is necessary that a majority of animals receive the appropriate drug dose, the individual behavior of animals raised in large flocks/herds affects the proportion of animals which receive optimal treatments as it has been demonstrated on swine. In poultry, drinking water is the most common route of administration, but little is known on the quantity of water really consumed by poultry and its variation between individuals (only flock-level consumption data are usually available). In large animal populations, continuous animal observation is basic but it also requires substantial manpower that is not easily available. As a consequence, farm animals are often treated only in case of clinical signs when the infection has already developed to a late stage. Mass treatment and late diagnosis of pathological conditions underline the lack of adequate observations and the need of early recognition, by skilled trained personnel, in detecting the first symptoms of the disease.

4.3.2 Identification of stakeholders' desired impacts

Stakeholder maps

Stakeholders were identified in the framework of WP1 activities. A stakeholder map and influence diagram was produced for poultry and swine, based on ROADMAP partners expertise and a series of interviews.

For pigs: Within WP1, interviews with 11 people were conducted between July and september 2020 (9 quality manager and veterinarians of 5 organizations of producers representing 55% of French pork production, 1 quality manager of a big French meat processor and 1 quality manager of a big retailer). Due to the Covid situation, all the interviews were conducted by phone or visio call. They were recorded and fully transcribed, and anonymized for the thematic analysis. Within WP2, 18 pigs farmers were interviewed, by phone or visio call, of which about half in conventionnal production and half in antibiotic free insurance schemes, from October to December 2020. The interviews have been recorded and fully transcribed and will be analyzed in February 2021.

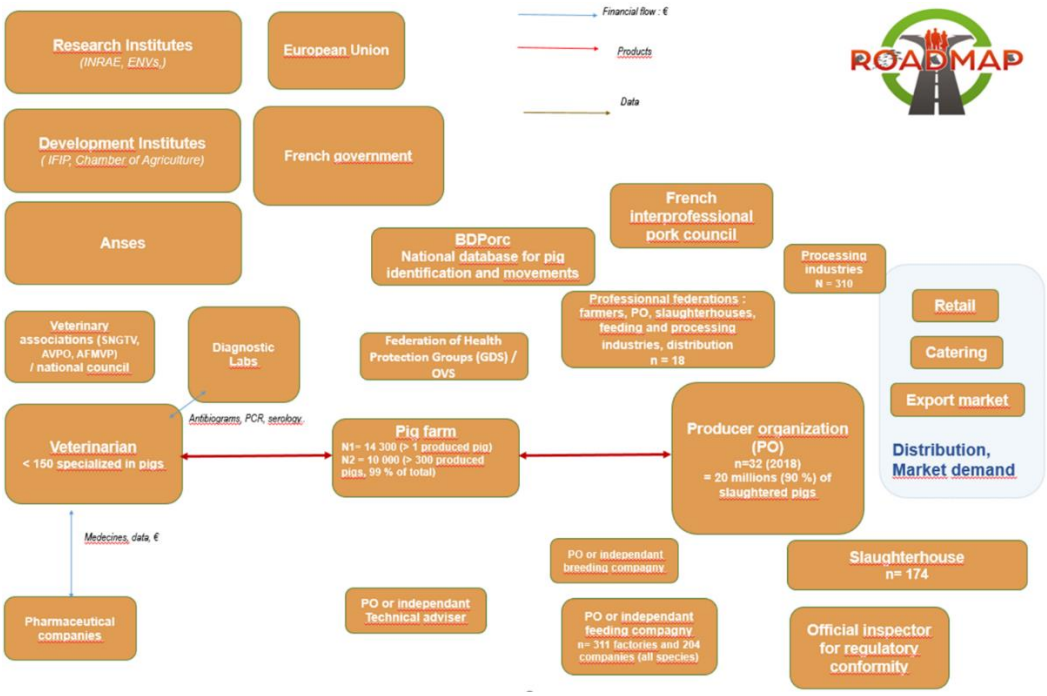

***Figure 8**: Stakeholders' map for the pig sector*

For poultry: 15 stakeholders were interviewed (production managers, farmer, president, technical advisor, veterinarian of producers' organisations; hatchery CEO; retail company; supply chain manager) either face to face, by telephone or visio-call.

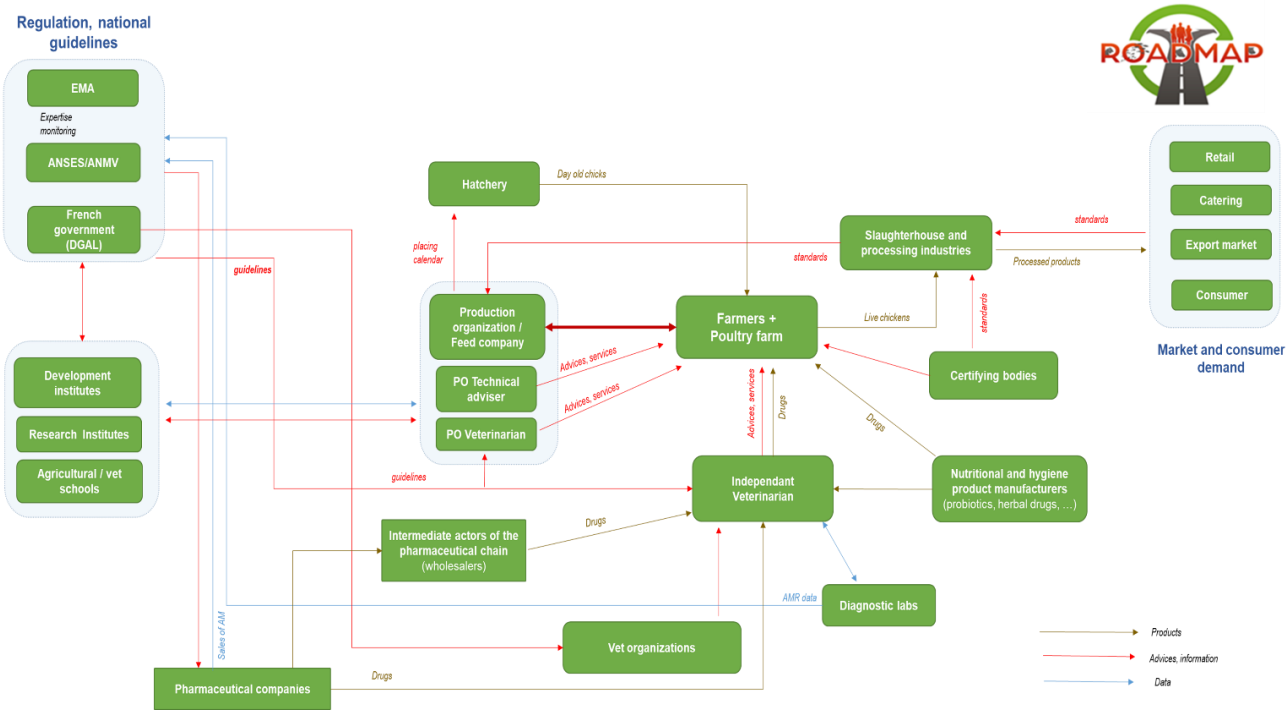

***Figure 9**: Stakeholders' map for the poultry sector*

Stakeholders' behaviours, practices, knowledge and motivations:

A first overview of stakeholder's behaviours, practices, and motivations was obtained from those interviews. Although a wide range of actors has been interviewed, behaviours and motivations are described only for stakeholders who have been approached for LL activities.

Farmers

Farmers are considered having a high influence over antibiotic use through several practices they apply on their farm. However, they have low power since they don't have power on some technical choices that can affect antibiotic use, especially in integrated sectors such as poultry (feed, day-old chick quality…). However, they can decide investment priorities (biosecurity, building, water quality…) but this investment highly depends on their financial capacities. Farmers can share innovative practices among each other through formal meetings organized by the cooperative, through regular discussions with technicians and veterinarians or through informal exchanges. As a whole, their feedback about adopting new practices, technologies or investments is paramount in the industry organization (average production costs, expected returns…) and used by POs, R&D institutes, Government. Finally, PO president, COOP directors or Interbranch association president are usually farmers. Farmers need to use antimicrobials to ensure animal health and welfare. Antimicrobials are sometimes considered the most effective and immediate way to reduce production losses risk, and the ratio between costs (of antibiotics) and benefits (in terms of performance gains) can constitue an obstacle to the reduction of antibiotics use by livestock farmers. The major cost is production loss whereas vaccines are only a minimal part of costs. By securing production levels and technical performances, the possibility of using antibiotics acts as a form of income insurance. The farmer's risk aversion can depend on a wide range of things (recent investments, debt ratio, income, past experiences…) which will have an effect on the decision to treat or not. In case the farmer is producing under an antibiotic-free label, he generally earns a price premium from the PO for respecting specifications which gives an incentive not to treat. However, the decision not to treat is a trade-off between the risk of mortality and the risk of losing the premium. Moreover, private labels usually include larger specifications than just antibiotic-free production (often includes animal welfare and/or non-genetically modified feed specifications) making it hard to isolate the premium specifically associated with antibiotic-free production.

Technical advisors

A technical advisor follows several farms of the PO, collects and interprets information provided by the farmer and data such as farm registery (technical performances, feed, …) to provide advice to the farmer based on his expertise of the individual situation of the farm in terms of characteristics of its buildings (age, quality), breeding management, practices and sanitary context. They have strong normative power, as they give advice and raises awareness on "good farming practices". Whether considering biosecurity or the use of antimicrobials, the informants almost always describe the quality of this relationship as central to behavioral change. Being in contact with other farmers and knowledgeable about poultry/pig production in general, the technical advisor usually benefits from a high legitimacy among farmers. Technical advisors being very legitimate and in close contact with farmers, they provide advice – in coordination with the veterinarian - that are often followed by farmers in case of uncertainty (for instance advice on when to contact the veterinarian). Technical advisors have a balanced interest for the use of antibiotics. Their goal is to both satisfy PO's productive plans and to ensure that they keep a good legitimate influence over farmers to do so.

Veterinarians

Veterinarians perform diagnostic of diseases in farms, prescribe antimicrobials and other drugs, sell antimicrobials and other drugs including vaccines, provide advice on antimicrobial use and alternative measures to improve animal health in the farm, and oversee farmers' practices. In the French Public Health Code, the veterinarian is designated as the only prescriber of veterinary drugs (including antibiotics) subject to medical prescription.
Veterinarians have high power since they are responsible for the prescription of antimicrobials, and can refuse to prescribe antibiotics. Veterinarians rely on regulation to change practices (e.g. no prophylactic use, antimicrobial susceptibility testing before prescription which is mandatory for critically important antimicrobials, …). Some structures can also provide tools to quantify antimicrobial usage to farmers and monitor AMU on farms. Veterinarians have high legitimacy among other stakeholders (farmers, technicians, PO) ; their knowledge and experience regarding management of animal health is recognized. This legitimacy is reinforced by the French Public Health Code which recognizes veterinarian as the only prescriber of veterinary drugs subject to medical prescription.
Veterinarians have high interest in antibiotic use since their sources of income largely depend on drug sales (antibiotics in particular). Little information is available on the share of antibiotics in veterinary practices accountability for pigs and poultry practices. In 2013, a report by the French Food, Agriculture and Rural Areas Council estimated this figure to be around 60% for farm animal veterinarians in general, and up to 80% (including a high proportion of antibiotics) for industrial veterinarians (Dahan et al. 2013, p. 20). Drug sales have been almost the only way of monetizing veterinary services in the pig and poultry farming sectors and making professional expertise profitable. They have to get more legitimacy selling vaccines and other preventive drugs (in the French economic system, these preventive products are often sold to the farmers by the producers' organisation). New economic models (practice accountability, contractual arrangements with the clients, advice etc.) that do not rely on drug sales still have to be developped. Veterinarians contribute to influence the system to transition towards a more prudent use of antibiotics and a lower risk for antibiotic resistance. Their interest may also be non-financial.

Producers' organisation (PO)

The mission of producers' organisations is to organise the collective marketing of the production of their members and provide them with technical support and economic and financial support. In pork, the thirty or so producers' organisations in France differ according to their degree of involvement in upstream (feed production, genetics) and / or downstream (slaughter, processing, marketing). The producers' organisation coordinates actions between farmers, input suppliers, and slaughterhouse to adjust production according to demand. In poultry, the main part of its work is to organise the production planning (placings, removal, transport).

Being a coordination body, a PO cannot use regulation, force or threats to enforce additional standards. Coercive power on a farmer can however be high in a sense that PO have the power to renew or not the production contract in the case of poultry (integrated chain) or to impose specifications incorporating specific constraints on the use of antibiotics, animal welfare or the type of food or genetics in pig sector, which is an important power especially in low animal density territories. Through its contracts ou insurance schemes with farmers, a PO can impose technical choices (especially feed, …) or specifications to answer specific client (non-GMO, antibiotic-free…). The income of the farmer per animal sold can vary depending on its performances and its compliance to these specifications through bonuses or penalties. PO can also provide training sessions and technical advice to farmers (on biosecurity for instance). Being input suppliers and veterinarian clients, PO have financial and market power

that increases depending on the production volumes. In case of antibiotics, key informants report that some PO are able to have power on suppliers or veterinarians to comply with specific protocols and in some cases ask for a refund if an antibiotic treatment could be linked to their responsibility. Apart from the economic incentives, different PO implies different management models that can play an important part in the farmer's choices of action. For instance, some PO are cooperatives owned by other farmers, with a different perspective than PO that are linked to an industry (slaughterhouse or feed industry). Moreover, the economic theory shows that production contracts have three functions: insurance, performance incentive and optimization of coordination costs (Magdelaine et al., 2015). There is an antagonism between performance incentives and insurance function that leads to wide variety of contracts types. The contract provided by PO is a normative framework, that leads to a relative normative power. PO have their own objectives, that are not necessarily in line with individual farmer's interests.

The PO is an intermediary body whose aim is to optimize transaction costs between several economic agents: breeders, slaughterhouses, input suppliers and feed industries. The PO's basic interest is that this coordination is financially neutral for them (respect of schedule) and their farmers (loyalty). In case their farmer use antibiotics, they have high interest in antibiotic use in a sense that using antibiotics in the case of a sanitary event secures production according to plan and reduces production variability (reduces market risk). In case the production risk is compensated in some way, then the interest in antibiotic use is decreasing. In the case they committed to some specifications with clients (no critical antibiotic use, antibiotic-free label), they have a high interest in antibiotic reduction since its use would imply a loss of revenue. If the interest is financial, the challenge of these specifications is also to respond to the concerns expressed by citizens and consumers. In this sense, the interest is also to improve the image of livestock farming and animal products, to reconcile citizens with farming and consumers with animal products.

French Ministry of Agriculture (DGAL)

The French general directorate of food (DGAL) of the Ministry of Agriculture has high interest in antibiotic use and resistance. DGAL is in charge of implementing in France the policy directions defined by the European Parliament and the European Commission, as well as strategies impulsed by international organizations (WHO, FAO and OIE). DGAL exercises oversight of food safety and quality at every stage in the food supply chain, in addition to the health and protection of both animals and plants, working in conjunction with the various stakeholders: farming professionals, veterinarians, non-profit associations, consumers, and others. It draws up the regulations that govern its core tasks and verifies their proper application, working through decentralised services in France's departments and regions.

DGAL has very high coercive power since it is in charge of drafting regulations regarding animal health and antibiotic use. Through its offices out in France's departments and regions, DGAL oversees farmers and veterinarians' compliance and has the power of formal notice if practices contravene the law. DGAL can use financial incentives so as to promote "good practices" and engage stakeholders. Two national plans ("Ecoantibio 1" 2012-2017 and "Ecoantibio 2" 2017-2021) have been launched under the auspices of the Ministry of Agriculture. Every year since 2013 approximately €2 million has been devoted to projects for action or research – of which some are conducted by the industry. Also, a tool for measurement of antimicrobial use based on veterinary prescription data is under process under the umbrella of the French Ministry of Agriculture. DGAL conveys very high normative power since it is important for most stakeholders to be in line with regulation. Through communication and information tools, Ecoantibio plans aim to convey new social norms on "good practices" regarding AMU. In September 2019, a new information campaign was launched with livestock farmers and veterinarians

in mind, the aim being to ensure all concerned remained involved: "Antibiotics: As needed –When needed". Whenever it provides new regulations / official control, it is usually meant to be followed as soon as possible. However, when a new law is enacted, its application on the field may not be immediate.

Pharmaceutical companies

In France, around thirty veterinary drug production establishments are present on the market, most of them manufacturing both human and veterinary drugs. Those companies vary greatly in size, with some of them being French small or medium-sized firms and other belonging to large international groups with headquarters located abroad. The market is shared quite unevenly: the top four laboratories account for 59% of the market for animal health products, the top ten laboratories account for 93% of the market shares[2]. They have high interest in antibiotic use and resistance. Their interest is financial through the selling of antimicrobials or other drugs that may limit the use of antimicrobials (mainly vaccines).

Pharmaceutical companies sell antimicrobials and other drugs to veterinarians. They also provide continuing education on their products and animal health to veterinarians. As business industry they can use monetary incentives towards veterinarians. Specifically with regard to antibiotics, commercial agreements between pharmaceutical companies and veterinarians are now prohibited. Law, known as the 'removal of the 3 Rs' (discounts, price-cuts and rebates), prohibits pharmaceutical companies from paying back-margins to veterinarians according to their prescription volume (a practice that had developed in the 1990s and which encouraged practitioners to achieve certain sales volumes in order to benefit from more attractive prices)[3]. At the same time, the strong development of vaccines and the negociation of back margins on this type of products is an incentive for the purchase and prescription of preventive medicines. They also have some normative power through their prestige, the esteem from veterinarians and the relationships with veterinarians. Through the intermediary of pharmaceutical representatives, pharmaceutical companies seek to promote their products and advertise them to distinguish themselves from competitors. Autogenous vaccines companies develop drug solutions that are promoted as alternatives to antibiotics. Their growing economic activity has therefore been concomitant with legislation requiring a reduction in the use of antibiotics. They can promote their brand image as laboratories at the forefront of pharmaceutical innovations. They have poor legitimacy as they are perceived as having conflicting interests.Today, negociation with veterinarians is not only commercial. The volumes negotiated are based on production capacity. The laboratories control the production chain and can thus guide the choice of products according to the production capacity. The major players in the pharmaceutical industry are losing interest in antibiotics.

At this stage, these stakeholders have not yet been asked which AM-related impacts they wish to contribute to through the ROADMAP project .

[2] https://www.simv.org/actualite/chiffres-2017-aiemv

[3] The back-margin system has been forbidden by law in 2014. It was a business model that used to allow veterinary practices to get additional discounts on antibiotics (by the pharmaceutical companies which were supplying them) if they managed to reach a certain annual volume of sale. This system was considered to encourage overuse of antibiotics.

4.3.3 Ex ante impact assessment

Ex-ante assessment will be carried out based on participatory meetings planned with stakeholders in the framework of living-lab (LL) activities. Two problem trees have been built by ROADMAP partners following a first series of preliminary meetings conducted between the French living-lab coordinator and the WP6 leaders. Each tree corresponds to a topic (alternatives to antibiotics ; tools for AMU monitoring) which will be submitted for discussion to stakeholders during the first LL meeting. Once a final choice has been made by stakeholders on the LL topic, desirable future and impacts will be identified by stakeholders in further LL meetings.

4.4 Italy

4.4.1 Presentation of the case study

General context

Sales of antimicrobials for animals in Italy remain high compared to most other European Union Member States according to the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project, despite ESVAC data showing a 42% reduction during the period 2010-2018. In this trend a significant contribution was related to the reduction of the use of quinolones and fluoroquinolones, polimixins and macrolides. However, the 2018 value is still the second most relevant in Europe with the majority of sales to be attributed to Tetracyclines (72,6 mg/PCU) and Penicillines (68.7 mg/PCU). The national One Health action plan (NAP) on AMR was adopted in November 2017 in Italy. However, several of the measures proposed in the NAP are still voluntary. An Electronic Veterinary Prescription (e-prescription) system was adopted from 2019 and serves as the main AMU monitoring system for the country's authorities. This system provides data that are used by the authorities to focus official controls on high antibiotic-using farms or high-prescribing veterinarians. ClassyFarm, a voluntary risk assessement tool is also being implemented in the country with the aim of categorizing the risk of farms in the field of veterinary public health. It allows the detection, collection and processing of data relating to the following assessment areas: biosecurity; animal welfare; health and production parameters; animal feed; consumption of antimicrobial drugs and injuries found at the slaughterhouse. Some of its modules are becoming progressively mandatory for farms in specific sectors. In addition, 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 (specially 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. In addition various information measures, awareness campaigns and training activities have been undertaken, involving veterinarians, farmers and other stakeholders. From the other side, one of the mains problems still faced in the country concerns the fact that for some farmers it might still be cheaper to continue using antimicrobials rather than investing in improvements in farm infrastructure or husbandry systems.

The case studies

Health constraints linked to AMU in the Italian poultry sector

In 2018 the estimated Population Correction Units (PCU) for poultry in Italy corresponded to 18.7% of the 3.819 Italian PCU of all food-producing animals. At National Level, a first Plan for the responsible use of veterinary medicines and the fighting against antimicrobial resistance in poultry was adopted in 2015 for the period 2015-16, which was followed by the 2017 NAP. In the poultry sector, in Italy, thanks to the high level of integration of poultry companies, a fast decrease on the use of antimicrobials was observed with a percentage of antibiotic-free production raising above 30 % of total production. Antimicrobials are used to treat infections associated to respiratory tract, foot pad lesions and gastroenteritis. Bacterial infections, in particular respiratory ones, are often secondary infections after a primary viral infection.

Based on this knowledge 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.

Despite all the measures applied there are important constraints that prevent a further reduction on the use of antimicrobials: 1) the implementation of biosecurity is limited in old buildings in which windows are not present, essential for the welfare of animals,; 2) antimicrobial treatments are applied in feed or water (increasing potential environmental contamination) and always as metaphylaxis approach. From 20 to 40 thousand animals are stocked in the same holding: when specific symptoms are observed by farm veterinarians, the whole flock is treated. In broiler conventional rearing system it seems impossible to separate sick animals from healthy animals.

Health constraints linked to AMU in the Italian pork sector

The main constraint limiting the diffusion of harmonized good practices in the Italian pig sector is the high fragmentation of the production system. Around the 34-40% of the production is integrated, while the remaining 60-70% is divided in mid or small farms. In the pig sector since 2020 the risk assessement tool ClassyFarm is mandatory for all farms and the assessment is the responsibility of the veterinarian of the farm. Moreover, periodically the Local Health Unit-LHU veterinary (public body) verifies the score by an audit. Another action that affected the use of antibiotic 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 antibiotics. This fact strongly affected the use of colistin on weaned pigs, which today is almost zero. Consequently, the use of therapeutic doses of ZnO increased, replacing colistin. In pigs, especially at weaning, the first way of administration of antibiotic is orally, while in suckling pigs, sows and fattening pigs (apart the first week post housing from site 2 to site 3), the injection is the first way of administration. Anyway, the weaning phase is the one where most of the antimicrobials are used in pig production, so specific actions on this production phase could significantly affect AMU on the Italian pig sector.

Together with the institutional action, the request of retailers for pork meat produced with specific claims or labels (e.g. welfare, antibiotic-free, organic), coexist in the process of reduction of the AMU in the pig food chain. Farms included on this process are usually associated to large cooperative groups or part of the integrated groups that can guarantee to the retailers a constant provision of meat.

Concerning vaccination, apart from the obligatory ones, the adoption of specific vaccination plans targeted for each farm gained consensus in the last year. The Experimental Zooprophylactic Institute (IZS), coordinates a project to produce vaccines targeted on specific pathogen strains of each farm. Moreover, for colibacillosis disease, the diffusion of oral vaccination increases the resistance of the pigs against *E. coli* F4 and F18. Other preventive strategies based on the improvement of the external biosecurity measures have been recently adopted due to the Covid-19 outbreak as well as the risk of diffusion of African Swine Fever (ASF) that has already reached some EU countries. This increased biosecurity could have a positive effect on the general health status of farms (to be demonstrated in the next year).

Together with the aforementioned strategies, the adoption of feeding strategies based on low crude protein content and the use of feed additives like acidifiers, crystalline amino acids and probiotic, concour in increasing the natural resistance of pigs against pathogens.

4.4.2 Identification of stakeholders' desired impacts

Identifying stakeholders and producing a stakeholders' map

For identifying stakeholders and producing the stakeholders' map for the pork sector, the data collection was based on a direct knowledge of the production system (experts knowledge). In the poultry sector, the data was collected by key informant interviews. Around 10 interviews were conducted by phone and face to face to key persons involved in veterinary official controls as well as within the poultry company of the case study. Moreover, researchers with a long experience of collaboration with poultry industries, veterinary official controls and feed additives producers were interviewed. Data of interviews were transcribed. To understand the role of each stakeholder and the type of connections to other stakeholders, websites and document available through the websites of relevant stakeholders were reviewed.

The results revealed the main interests and influences of the stakeholders directly involved in the antimicrobial supply chain. In summary, In Italy, the AMs developed by the pharmaceutical companies must be approved by Italian government via the Ministry of Health. The Ministry grants the marketing authorization to the company, which provides the competent authority (Local Health Unities-LHU) with all data relating to the volume of sales and prescriptions. The Ministry of Health is responsible for the controls on AMU together with its subordinated agencies. Pharmaceutical veterinarians on behalf of the pharmaceutical companies propose medicinal products to the industrial integrated group (i.e. to the herd veterinarians chief). The choice of the drugs to be used is not up to the individual herd veterinarians nor to the farmer, but to the management of the group. Italian law prohibits pharmaceutical companies from directly selling drugs to farmers.

Since 2019 the drug traceability system (Electronic Veterinary Prescription) has been set up replacing the paper system. The system tracks the entire flow of veterinary drugs from producers to retailers (traceability database) up to the subministration of medicines to the animals (e-prescription database). A fully computerized system based on electronic prescriptions allows to trace veterinary medicines and particularly antimicrobials, from the production to their administration to the animals.

In a franchising-like association with the farmer, the most common production system in the Italian pork and poultry sectors (both Italian ROADMAP case studies), the integrated company provides most

of the inputs and uptakes the related costs, including those related to veterinary medical products. The integrated company veterinarian manages the health status of the farm and the choices related to the medication. The integrated company can also produce medicated feed, having an even stronger influence in the AMU. In such integrated system, the farmer provides labour, the buildings and energy/electricity, having very low decision power over the AMU and other production practices.

The veterinary service of the LHUs ensure by means of repeated inspections that the legal requirements relating to veterinary medicines use are complied with. The controls involve all the players in the distribution system of veterinary drugs (authorized wholesalers, pharmacists, veterinarians and farmers). The inspections concern: active substances and quantities of AM kept in stocks by authorized farmers; records of the veterinary medicinal products administered to farmed animals, the criteria used to choose the AM products, purposes of use (prophylactic use), species allowed and justifications provided for the treatments.

The Experimental Zooprophylactic Institutes (IZS) are public health bodies, part of the National Health Service, working for animal welfare, food hygiene and quality, health and hygiene status of the farms, epidemiological surveillance, research, staff training, laboratory support and diagnostic in the contest of official food controls. It provides a monitoring system on antimicrobial resistance in veterinary medicine in the Italian territory. It operates in the international networks of monitoring and harmonization of analytical methods of AMR.

Certification agencies guarantee the control of “reared without antimicrobials” labels at national level, according to the regulations established by the Ministry of Agricultural Food and Forestry Policies.

4.4.3 Ex ante impact assessment

For the Italian case studies of pork and poultry sectors, both upcoming living labs are being prepared and will be the occasion to ask stakeholders about their desired impacts and start the ex ante impact assessment process.

4.5 Vietnam

4.5.1 Presentation of the case study

The Vietnamese case study is about marginal poultry.

AMU in marginal poultry in Vietnam

One study showed the presence of 28 antibiotics belonging to 10 different classes in commercial formulations and 63% of them contained at least 2 antibiotics (Carrique-Mas et al., 2015). The most commonly used molecules are: polypeptides, tetracyclines, penicillins and aminoglycosides. On the other hand, in terms of quantity administered, the molecules found most in compounds are: penicillins, lincosamides, quinolones, and sulfonamides/trimethoprim. Analysis of 20 antimicrobial progeny re-

vealed the presence of the following 12 AMs, from the most to the least common: colistin, oxytetracycline, gentamicin, tylosin, doxycycline, amoxicillin and enrofloxacin to trimethoprim, streptomycin, tilmicosin, erythromycin and neomycin. The most widely distributed AM active ingredients at the beginning of the cycle are oxytetracycline, thiamphenicol and colistin (Cuong et al., 2019). In another study the most commonly used antibiotics were colistin, followed by oxytetracycline, tylosin, doxycycline and gentamicin (Carrique-Mas et al., 2019). There are reportedly 236 veterinary medicinal products using 42 different antimicrobial active ingredients, and 76.2% of them contain AMs considered critical by the WHO. Livestock farmers use up to 38 different AMs for treatment and the most frequently used are: colistin, oxytetraycline, tylosin and doxycycline; representing 53.1% of the AMU (Choisy et al., 2019).

In the Mekong delta farms, the adjusted amount of AM is 26.36 mg used/week/chicken and 690.4 g per 1000 chickens produced (Carrique-Mas et al., 2015). On average chickens consume 791.8 mg/kg active AM ingredients during treatment and 323.4 mg/kg of chicken sold (Cuong et al., 2019). The number of daily doses distributed per kg of live chicken per 1000 days is 382.6 (Cuong et al., 2019). Another study conducted in small and family-run farms calculated this number to be 370.6 (Trung et al., 2015). These numbers are indicative of an excessive AMU and much higher than that applied in Europe.

Regarding medicated feeds, among 1462 commercial feed formulas analysed (including 485 for poultry), only 64.4% indicated the composition and among them 43.7% included at least one AM (Cuong et al., 2016). It has been estimated that 77.4 mg of antimicrobials in feed are used per kg of live chicken. The AMs most commonly found in poultry feed are bacitracin, chlortetracycline and enramycin (Cuong et al., 2016).

Differences in perceptions and attitudes towards AMU

A study conducted in the Mekong Delta region using Q-sorting and a participatory approach with 125 poultry farmers and 73 counsellors showed heterogeneity in practices and perceptions regarding AMU (Truong et al., 2019). Indeed, some farmers (30.8%) are aware of the attitude to adopt regarding AMU and have knowledge, others (26.9%) are dependent on AMU, some (23.1%) use AMU on their own initiative without consulting and finally others (19.2%) have no knowledge about AMU. The advisors also have divergent perceptions: some (36%) think that farmers lack knowledge, others (36%) think that farmers can improve, and finally some (23.1%) think that farmers are dependent on external advice from advisors. These gaps in knowledge and beliefs are all factors in AMU, which may even be considered an integral part of "good farming practices" by some farmers. Indeed, AMU reduces the anxiety of farmers who feel that they are avoiding the risk of disease and therefore have the greatest number of healthy animals to sell at the end of the production cycle. It is important to understand and encompass all these perceptions and motivations in order to propose solutions adapted to the greatest number of people.

Factors of unprudent AMU

Different actors play a role on unprudent AMU in marginal poultry in Vietnam.
Researchers have observed that the highest AMU uses were associated with the broiler production chain (Carrique-Mas et al., 2015). Farms where "all-in-all-out" (often associated with medium-scale farming) is practiced use fewer.

Small family farms (<200 chickens) use more AM compared to medium size farms (200-2000 chickens). This last observation is in contradiction with a more recent study conducted in another region of Vietnam, which on the contrary showed a correlation between high AMU and a higher number of animals in the farm (Carrique-Mas et al., 2019). This suggests that the actual association of individuals and AMU depends on the region studied.
AMU is more important in cases of bacterial infections and particularly in cases of pasteurellosis, colibacillosis and mycoplasma. The majority of AM is administerered prophylactically, regardless of the level of biosecurity. AMU provides a sense of security by preventing diseases (Carrique-Mas et al., 2015; Nguyen et al., 2016).
The majority of AMs are administered during the first and especially the second month of the production cycle, a period when the risk of disease is considered more important due to dietary and environmental changes. The vaccination period is also considered at risk, and AMs are used to prevent secondary infections. Some farmers also AMs for prophylaxis during the transition period between the dry and rainy seasons (Truong et al., 2019).
In the event of an epidemic, farmers treat non-sick animals as a preventive measure rather than implementing biosecurity measures. AM are also used as growth promoters. Half of AMU happens during weeks without episodes of illness (Choisy et al., 2019) and 53.7% of episodes of bacterial disease are not resolved either by the absence of treatment or by the ineffectiveness of the treatment administered. For episodes where an AM was given, the failure rate is 57.4% for all pathogens combined and 23.8% when a bacterial agent was actually the cause. In addition, many farmers do not follow treatment duration and dose recommendations, increasing the risk of antimicrobial resistance (AMR).

Some farmers are reluctant to consult with private veterinarians and veterinary pharmacies who would a priori be best qualified to advise on the administration of AM. In addition, some farmers rely on their own experience and may not have sufficient knowledge. AMU is linked to the presence and density of veterinary pharmacies in the vicinity of farms, thus facilitating access to AM.

There are moreover labelling defects on AM products. In a study analysing 20 of the most commonly used antimicrobial products in avian production in Vietnam and sold by 9 different companies, 8 of which were Vietnamese, 5% of these products gave no indication of use and 65% gave an indication for prophylaxis (Carrique-Mas et al., 2015). Only 40% of these products provided withdrawal times for the egg and meat industry. Batch analysis showed that only 28.8% of the latter actually met the limit and acceptable concentrations for all their active antimicrobial ingredients in the product and 29.7% of the batches were underdosed.

Although farmers consider that the price of AM is too high in comparison to the total cost of production and more expensive than implementing biosecurity measures and vaccination, they admit that they could not do without them. It is unclear whether an increase of price would lead to decreased AMU or to increased black market sales.

4.5.2 Identification of stakeholders' desired impacts

The identification of stakeholders and their links has been conducted between July and November 2020 through interviews of more than 20 stakeholders. Stakeholders from the private sector included: feed, drug, alternative products companies, food chain including chicken companies and retailers (sell products with no AB residues or organic). For Practitioners: technicians/veterinarians working for the

private sector and government. For researchers: Universities and national research centre, international researcher in the framework of ongoing project about AMU reduction. For policy-makers and administration: Vietnamese government (Ministry of Agriculture and Rural Development with the Department of Livestock Production (DLP) and Department of Animal Health (DAH). For multipliers: PGS Vietnamese Network, Vietnam Organic Organization (that are working in the development of organic production mainly in vegetables but start slowly to develop it for livestock production), cooperatives of farmers. At the same time, stakeholders have been classified as major partner /influential/ impacted based on results of the focus groups.

The identification of the stakeholders' desired impact will be conducted between July and December 2021 through a participatory modelling process in collaboration with stakeholders. There should be between 3 and 4 workshops

4.5.3 Ex ante impact assessment

The preparation phase will take place in January-February 2021, with a review of all the information collected from the interviews of the different stakeholders. The construction and measurement phases will take place between January and March 2021 and the confrontation in July-August 2021 through workskops combining the ComMod and ex ante impact assessment methods. The validation phase is scheduled for November 2021.

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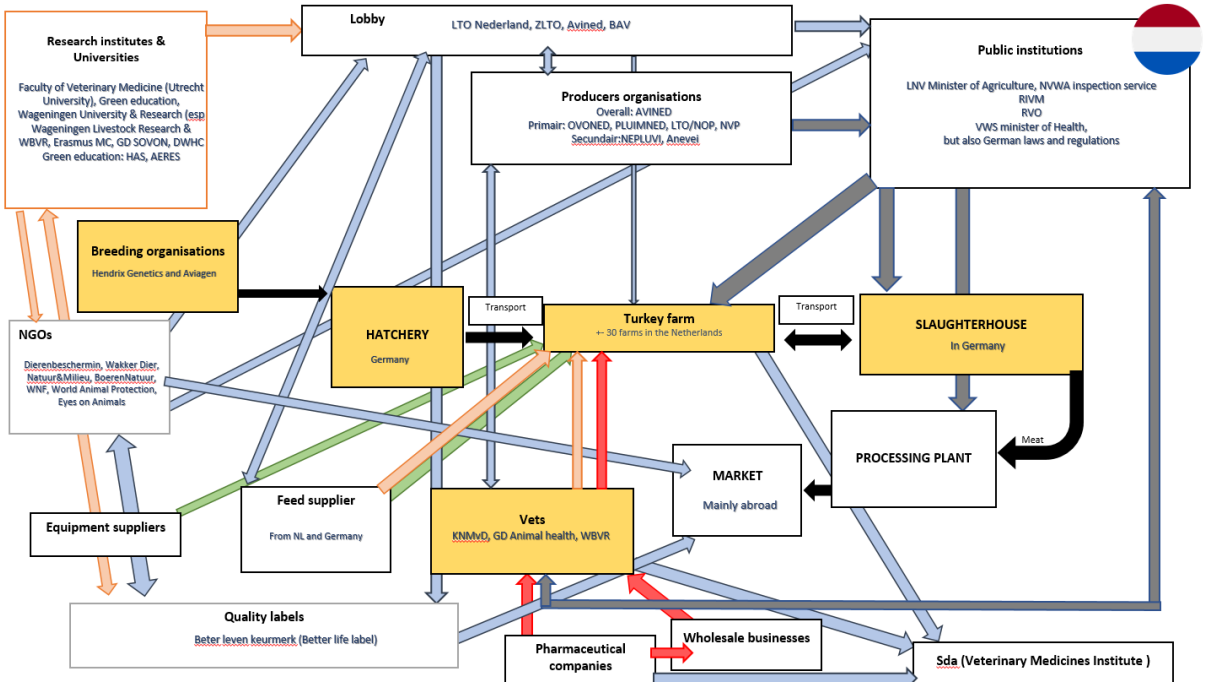
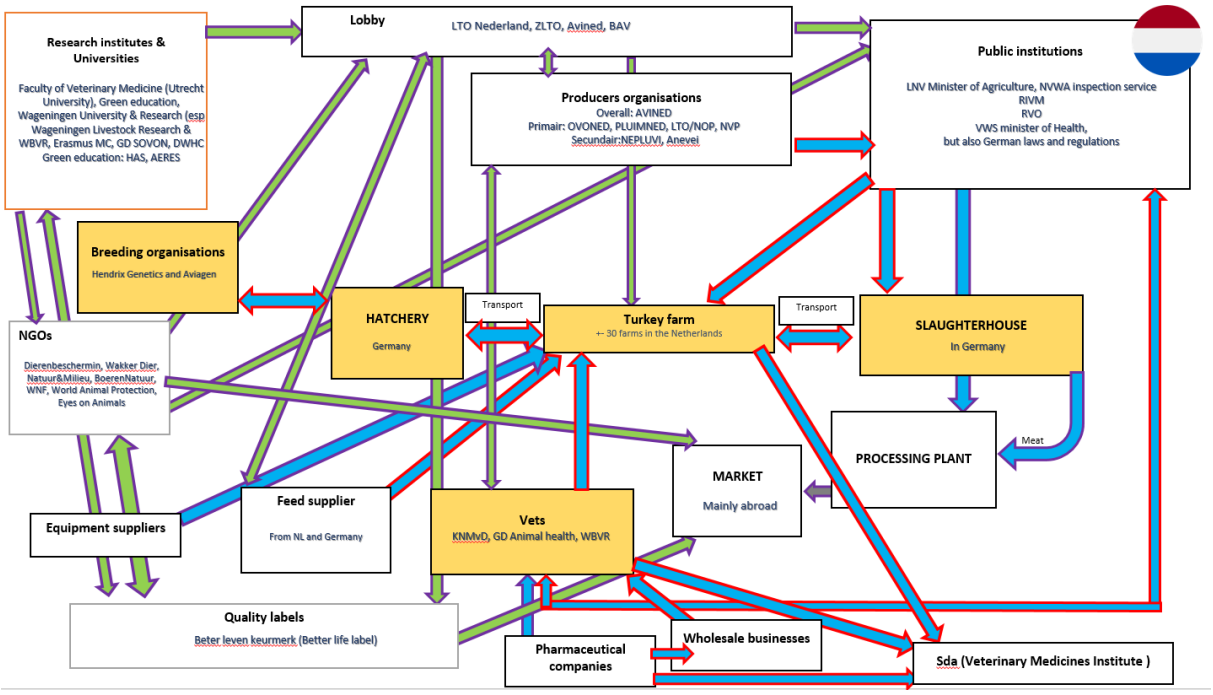
Annex 1: Stakeholders'map for the turkey case study in the Netherlands

The following information was collected as part of WP1 but is also useful for WP6 since identification and mapping of stakeholders is one of the first steps of impact assessment.



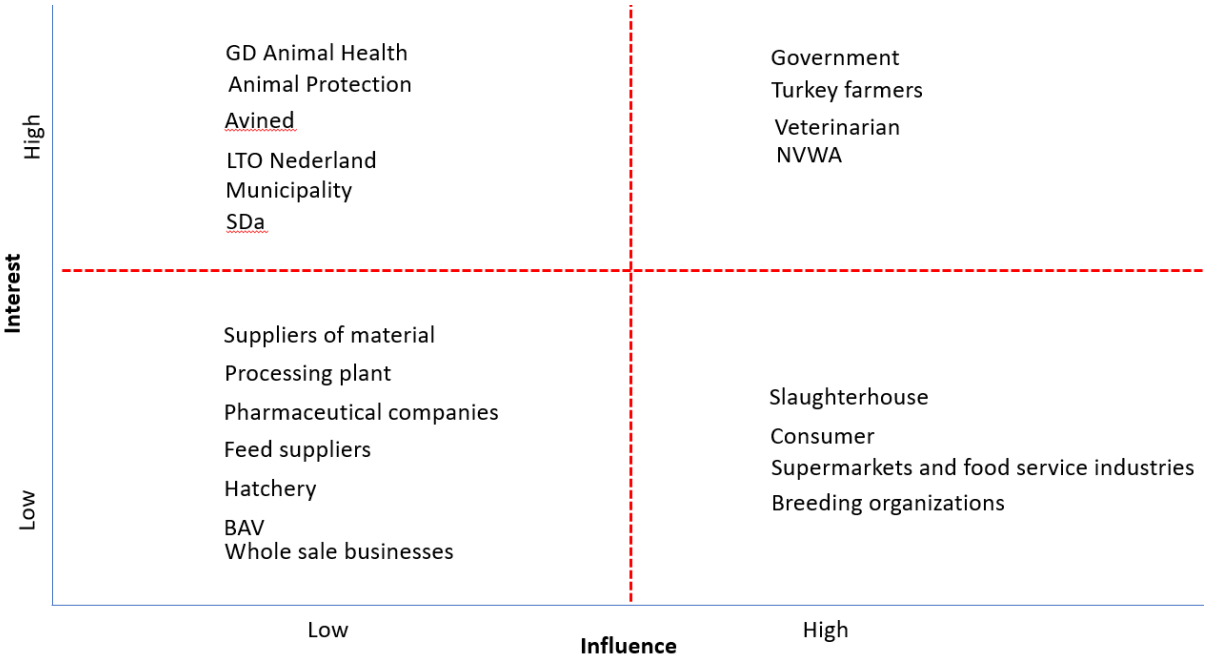
Grey are rules and inspections from the government. The government influences all stakeholders, but only the most import ones for AMU and AMR are shown here.
Orange arrows are flows that are knowledge or advise.
Blue arrows are flows of influence by exchange of information, negotiation, advise to policy makers or serving interests. They often don't involve the primary stakeholders involved in antibiotic use (yellow boxes; turkey farmer, slaughterhouse, vets, hatchery and breeding organisations), only vets supply farmers with advise regarding animal health. Stakeholders that have orange arrows are often involved in policy making or trying to influence the market or involved policy makers.
Black arrows are flows of eggs, animals or meat.
Green are material flows.
Red are flows of drugs/amu in the Netherlands.

Important to note is that a part of the stakeholders are based in Germany. Herefore, Dutch turkey farmers have to live up to Dutch and German laws and regulations and have less influence on the parts of the chain in Germany. For instance, no hatcheries and slaughterhouses are based in the Netherlands. Since only around 30 farms are producing in the Netherlands, there is not much "weight" for negotiation with those partners that could stimulate AMR. It is known that quality of poults is important in AMR and that the slaughterhouse has a big incentive (money) on kilo's and not on prudent AMU. Additionally, the market for turkey meat is mainly abroad, making it hard to find new markets or quality labels for meat that is produced with little AMU. This chain structure makes it hard to reduce AMU for Dutch turkey farmers.
The market in the end has an influence on all stakeholders, but for the sake of overview these interactions are left out of the map.



Formal interaction (fixed contracts/rules are made between stakeholders) = blue inside arrow
Informal interaction = green inside arrow

Strong interaction (important for reducing AMU) = red lining of arrow
Weak interaction (less relevant for reducing AMU although they can have an impact) = purple lining of arrow



Annex 2: Characterisation of stakeholders for the turkey case study in the Netherlands

Stakeholder	Type	Direction of influence	Strength of influence	Flows	Coercive power	Instrumental power	Normative power	Legitimacy	Urgency	Basis interest
Turkey farmers (+-30)	Business	Both influential and impacted	Strong	Material and immaterial	Low	High	High	High	Low	Financial
Feed suppliers	Business	Mainly influential	Strong	Material and immaterial	Low	High	Low	Low	High	Financial
Breeding organisations	Business	Mainly influential	Strong	Material	Low	High	Low	Low	Low	Financial
Hatchery (Mainly German)	Business	Mainly influential	Strong	Material	Low	High	Low	Low	Low	Financial
Veterinarian	Business	Both influential and impacted	Strong	Material and immaterial	Low	High	High	High	High	Financial
Slaughterhouse (Germany)	Business	Mainly influential	Strong	Material	High	High	Low	Low	High	Financial
Suppliers of material (stables, bedding...)	Business	Both influential and impacted	Weak	Material	Low	Low	Low	Low	Low	Financial
Pharmaceutical companies	Business	Both influential and impacted	Weak	Material	Low	Low	Low	Low	Low	Financial
GD Animal Health	Research	Both influential and impacted	Weak	Material and immaterial	Low	Low	Low	High	Low	Financial
Processing plant	Business	Mainly influential	Weak	Material and immaterial	Low	Low	Low	Low	Low	Financial
Animal Protection	Policy	Mainly influential	Weak	Immaterial	Low	Low	High	Low	Low	Non-financial
Supermarkets and food service industries (sales market)	Business	Mainly influential	Weak	Material	Low	High	Low	Low	High	Financial
Consumer (mainly abroad)	Business	Mainly influential	Weak	Material	Low	Low	High	Low	Low	Non-financial
Government	Policy	Mainly influential	Strong	Immaterial	High	High	Low	High	High	Non-financial
Municipality	Policy	Mainly influential	Weak	Immaterial	High	High	High	High	High	Non-financial
Avined	Intermediary	Both influential and impacted	Weak	Immaterial	Low	Low	Low	High	Low	Non-financial
LTO nederland	Intermediary	Both influential and impacted	Weak	Immaterial	Low	Low	High	High	Low	Non-financial
BAV	Intermediary	Both influential and impacted	Weak	Immaterial	Low	Low	High	High	Low	Non-financial
Whole sale businesses	Business	Mainly impacted	Weak	Material	Low	Low	Low	Low	Low	Financial
Sda	Research & education	Mainly influential	Weak	Immaterial	Low	Low	High	High	High	Non-financial

Annex 3: Summary of survey desired impacts results for the turkey case study in the Netherlands (preliminary results as of 21/01/2021)

This survey was filled out at the start of Living labs (iwhtin the framework of WP3) by 8 participants (4 veterinarians, 1 farmer, 1 employee farmers organisation, 1 researcher, 1 feed advisor). Below is the number of responses per answer and answers given for the open questions.

Question 1: Consider possible impacts in relation to AMU in the livestock sector in the coming 5-10 years. State how important you find the following impacts by giving them a score from 0 to 3 (0 no importance, 1 low importance, 2 average importance, 3 high importance). List other highly important impacts if they are not listed.

Farmers (1 participant):

Impact	Importance			
	None	Low	Average	High
Consolidation of relationships between farmers and veterinarians			1	
Decreased antimicrobial use			1	
Improved access to information/training on alternatives to AM treatments				1
Improved awareness of farmers on the antimicrobial resistance issue			1	
Improved credibility and visibility of antimicrobial-free animal food products		1		
Improved farmers' income				1
Improved offer of antimicrobial use advisory services		1		
Improved perception of animal farming by the civil society				1
Improved state help for investments into alternatives to AM treatments		1		
Increased economic value of antimicrobial-free animal products			1	
Maintained good health of animals				1
Prevented increase of farmers' workload		1		
Prevented increase of the costs for maintaining animals healthy		1		

No additional highly important impact listed

Veterinarians and others (7 participants):

Impact	Importance			
	None	Low	Average	High
Consolidation of relationships between farmers and veterinarians			2	5
Decreased antimicrobial use		1	1	5
Improved access to information/training on alternatives to AM treatments	1	3	3	
Improved awareness of farmers on the antimicrobial resistance issue		2	5	
Improved credibility and visibility of AM-free animal food products	2	1	4	
Improved offer of antimicrobial use advisory services		4	3	
Improved perception of animal farming by the civil society		1	5	1
Improved state help for investments into alternatives to AM treatments	3	2	1	1
Increased economic value of antimicrobial-free animal products	1	2	2	2
Increased recognition of the role of veterinarians in the response to AMR	1	1	2	3
Maintained good health of animals				7
Prevented decrease of veterinarians' income	2	3		2
Prevented increase of veterinarians' workload	3	2		2
Prevented increase of the costs for maintaining animals healthy	2	2	2	1

Other highly important desired impacts:

- Focus more on preventative instead of curative care
- Don't focus on alternative treatment, more on preventing treatment
- Awareness of the effect of antibiotic treatment in the development of AMR and risk factors
- Better communication that animal husbandry only has a small role in AMR development
- Steps in the production chain before primary farm and information about origin