



RESEARCH
PROGRAM ON
Livestock



Survey of Cluster 1 activities within the Animal Health flagship of the CGIAR Research Program on Livestock

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Alliance



CGIAR is a global partnership that unites organizations engaged in research for a food-secure future. The CGIAR Research Program on Livestock provides research-based solutions to help smallholder farmers, pastoralists and agro-pastoralists transition to sustainable, resilient livelihoods and to productive enterprises that will help feed future generations. It aims to increase the productivity and profitability of livestock agri-food systems in sustainable ways, making meat, milk and eggs more available and affordable across the developing world. The Program brings together five core partners: the International Livestock Research Institute (ILRI) with a mandate on livestock; the International Center for Tropical Agriculture (CIAT), which works on forages; the International Center for Research in the Dry Areas (ICARDA), which works on small ruminants and dryland systems; the Swedish University of Agricultural Sciences (SLU) with expertise particularly in animal health and genetics and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) which connects research into development and innovation and scaling processes.


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Cover photo: Animal health researchers collect serum samples from sheep in Horro, Ethiopia, to understand which pathogens are most common and that affect productivity, particularly reproduction. Photo ILRI/Barbara Wieland

Table of Contents

<i>Introduction</i>	4
<i>Background</i>	5
<i>Publications</i>	6
<i>Collaborations and partnerships</i>	7
<i>Scientific achievements</i>	8
Peste des petits ruminants	8
Porcine reproductive and respiratory syndrome	9
African swine fever	9
Foot and mouth disease	10
Respiratory disease	10
Zoonotic infections	10
Gender	11
Modelling.....	12
Disease priorities	13
Economic effects	13
<i>Impact</i>	14
<i>Conclusions</i>	16
<i>Acknowledgements</i>	18
<i>Abbreviations</i>	18
<i>Appendix 1</i>	19
<i>Appendix 2</i>	27

Introduction

The CGIAR Research Program on Livestock (CRP Livestock) is a sequel to the CRP 'Livestock and Fish' and has been running from 2017 to 2021, inclusive. 'Flagship projects' are thematic units within the CRP, and the Flagship Livestock Health (FLH) is the subject of the current review. FLH is organized into operational units called 'Clusters of activities' where the aim of Cluster 1 is to evaluate animal health constraints and threats by developing and deploying methods and tools for use in low-income countries *to identify the extent of animal health constraints and their impact on animal productivity and livelihoods*. Cluster 1 has committed to deliver two 'Product lines' dealing with.

1) **Assessment tools for significance of animal diseases** *where tools to prioritize diseases in different livestock systems including pigs, small ruminants and cattle are being developed, and,*

2) **Risk models and maps for animal diseases** *where risk assessments tools and studies on risks of emerging diseases are initiated including African swine fever (ASF), foot and mouth disease (FMD) and porcine reproduction respiratory syndrome (PRRS) as well as Peste des petits ruminants (PPR) where the aim was to support global eradication campaign efforts. To inform development of interventions new modelling approaches are being used to systematically assess the biophysical and socio-economic impact of livestock diseases.*

The aim of the present survey is to compile a synthesis description of the accomplishments of Cluster 1 by making an inventory of knowledge generated under the two product lines (e.g. papers, reports, briefs) and assessing evidence of uptake, i.e. to what extent the work so far has influenced disease control in target countries (cf. Appendix 2 for the ToR). Due to the interrelated nature of the two product lines, the outputs will mainly be considered with an integrated approach.

Background

The background to the CRP Livestock is the understanding of the great impact that an improved productivity of livestock farming will have on the livelihood of resource-poor farmers, most of them women, in low-income countries. Livestock products provide essential nutrients, not least important for growing children and pregnant and breast-feeding women, as well as valuable income to the farmers. But the productivity is limited by shortage of adequate feed, non-adapted breeding strategies, and by animal diseases where the lack of easily accessible animal health guidance further limits the conditions for a profitable and responsible animal husbandry. The purpose of the present Flagship which targets animal health constraints in low-income countries is thus highly relevant.

According to the aims of Cluster 1, focus in this survey is on pigs, small ruminants and cattle in four priority countries, viz. Ethiopia, Tanzania, Uganda and Vietnam. However, also some papers dealing with ruminant and pig infections in other countries are considered as they contribute to the outcomes of the CRP. The publications included in this assessment are those reported in 'MARLO' (Managing Agricultural Research for Learning and Outcomes; <https://marlo.cgiar.org>), although papers on poultry and aquaculture are not considered due to the purpose of this Cluster. Also, work on ticks in Tunisia will be reviewed separately.



Researchers are working with farmers in Uganda, conducting training sessions to teach them better and more appropriate herd management practices to help control the spread of disease and contribute to greater livestock productivity. Photo ILRI/Kabir Dhanji

Publications

As a result of the work within Cluster 1, a total of **57 publications have been produced** between the years 2017 and present day (cf. Appendix 1).

Forty-two of the papers are published (one of them still under review) in relevant international **peer-reviewed journals**. Most of these journals are significant and of good ranking, for example 'Acta Tropica' (1, 13), 'Frontiers in Veterinary Science' (18, 44, 48, 50, 55). 'One Health' (45), 'PLOS one' (53), 'Transboundary and Emerging Diseases' (21, 22, 31, 52, 56), 'Veterinary Parasitology' (10). Nine of the publications are in the format of reports, manuals or briefs published by ILRI (23, 30, 36, 39, 40, 41, 42, 46, 49) and one by the National Institute of Animal Sciences in Vietnam (51). Based on the purpose of the Cluster, the latter types of publications are important and of considerable practical and strategic value. In addition, some material has been published digitally on the internet, for example a series of training videos/lectures utilizing YouTube as platform (38), which make them easily accessible.

Two **academic theses** have so far been the result of work within the Cluster; one PhD thesis on the parasite burden of pigs and their implications for public health in Uganda presented at the University of Berlin, Germany (9), and one MSc thesis on sheep pox in Ethiopia presented in 2017 at the Addis Ababa university, Ethiopia (2). An additional number of doctoral and masters students are involved in studies based on the Cluster agenda, but their theses are not yet finalized.

Geographically, 13 of the 57 publications are based on studies performed in Ethiopia (1, 2, 14, 17, 18, 19, 23, 28, 43, 44, 45, 46, 49), 11 in Vietnam (21, 22, 30, 31, 32, 33, 51, 52, 53, 54, 57), 6 in Uganda (3, 9, 13, 20, 50, 54) and 3 in Tanzania (5, 48, 56). Additional countries include Kenya (7, 15), Tunisia (4), DR Congo (11) and Uruguay (35).

As regards **livestock species**, 19 of the publications are dealing with pigs, 20 with small ruminants (sheep and goats), 6 with cattle and 10 with a combination of livestock species.

Apart from studies with a comprehensive approach (1, 2, 3, 8, 12, 18, 19), studies with the **pig** have focused on African swine fever (ASF) (3, 26, 47, 50, 51, 52, 53, 56), Porcine reproductive and respiratory syndrome (PRRS) (13, 21, 22, 30, 32, 50), and respiratory disease (4, 10, 18, 34, 54, 55).

In **small ruminants** the most purposeful and focused work within the Cluster has been that on epidemiology and control of Peste des petits ruminants (ECo-PPR) (11, 19, 38, 39, 40, 41, 42).

Reproductive performance was studied in goats (43) and abortifacive agents in sheep (44). The latter include some potentially **zoonotic agents** such as *Campylobacter*, *Chlamydia* and *Toxoplasma* (16, 17). Studies on zoonotic infections also include *Taenia solium* cysticercosis in pigs (20, 27), hepatitis E in pigs (33), echinococcosis (15), influenza A (6, 13), and bovine brucellosis (12). Work in cattle also include a study on the Nagana agent *Trypanosoma congolense*, and Foot-and-mouth disease (FMD) which was

addressed along with other biungulate livestock species in Vietnam (30, 31) and Uruguay (35).

Review papers are important scientific tools that are used to explain the state of knowledge in a particular field and to provide a critical evaluation of existing studies in order to identify and justify new research. As part of the work in Cluster 1 a good number of review papers are produced, addressing for example vector-borne diseases (1) and lungworm infection (10) in small ruminants, brucellosis in cattle (12), porcine respiratory disease in Africa (34) and other relevant subjects (6, 8, 37, 57).

The work in Cluster 1 was performed under the auspices of ILRI and to a lesser degree of ICARDA with Drs. Barbara Wieland (cluster leader until February 2021), Michel Dione (cluster leader from February 2021) and Hu Suk Lee as prime movers. Of the 42 peer-reviewed papers included in this survey, Dr. Wieland authored 22 papers out of which 10 as senior author, Dr. Lee 9 papers with 7 as first author and 1 as senior author, and Dr. Dione 8 papers with 2 as first author and 3 as senior author.

Collaborations and partnerships

The FLH/Cluster 1 has participated in collaborations and partnerships on specific diseases and other livestock health related issues. These include:

- a) African Research In Sustainable Intensification for Next Generation (Africa RISING) (17) that aims at promoting a sustainable intensification of mixed crop/livestock systems towards better food security and improved livelihoods in Africa.
- b) The FLURISK consortium studying drivers and risk factors for influenza A virus transmission across species barriers (6) where significant gaps in knowledge exist.
- c) The Global Burden of Animal Diseases (GBAD) program (29) that aims at creating information on the economic burden of livestock diseases to support animal health decision-making focused on the Sustainable Development Goals of the UN.
- d) The Infectious Diseases of East African Livestock (IDEAL) project (24, 25), a longitudinal cohort study of calf health conducted primarily in Kenya.
- e) The PALE-Blu project (36) on the prevalence and identity of bluetongue virus in sheep in key regions of sub-Saharan Africa.

In general, these collaborations do not appear so far to have generated publications where the links to Cluster 1 or FLH have been made evident.

Scientific achievements

Peste des petits ruminants

Peste des petits ruminants (PPR) is a viral disease primarily of sheep and goats, but also of camels and certain wild ruminants, with a high mortality and great economic impact in areas of Africa and Asia. OIE and FAO have set the goal of eradicating the disease by 2030, and accordingly there is a need for accurate diagnostic tools and animal health awareness in endemic areas which include east and west African countries. For example, in a study from the Amhara region of Ethiopia, PPR virus was detected in about half of 28 sheep and goats with suspicious clinical symptoms. This shows that the infection is present in the region and indicates the risk of spread to still free areas (19).

Thus, PPR has been an important target for research studies and the set-up of control strategies as part of the Cluster work. To that end a field researcher Manual (40) and a Toolbox (39, 42) were created to provide research and data collection support and evidence to the ongoing PPR control and eradication efforts in selected African countries (Eco-PPR). This approach is interdisciplinary towards understanding the socio-economic impact of PPR including gender sensitive challenges and opportunities for control. The work is further supported by making available instruction lectures and training videos on the internet (YouTube) (38). To reach stakeholders in francophone countries the manual is also made available in French (41).



Vaccinating goats against PPR in West Africa. Photo ACEI/Cheung-Wikimedia Commons

Porcine reproductive and respiratory syndrome

Porcine reproductive and respiratory syndrome (PRRS) is a viral infection of pigs that was first described in the 1980's in North America and is now endemic in many countries around the world. As the name implies, PRRS is causing reproductive failure in sows but also respiratory disease in younger animals.

Within Cluster 1 work on PRRS has been performed in both Vietnam (21, 22) and Uganda (13, 50). One Vietnamese study simulated the disease transmission in order to better understand the influence of contact patterns between farms and how this would inform the prevention and control of the disease. A main risk factor for PRRS is the movement of infected animals between farms, and one of the models demonstrated, under Vietnamese conditions, the benefits of vaccination of pigs in medium sized farms to reduce the transmission to pigs in small farms (22).

In a similar study in Uganda (50) it was concluded that large and medium sized farms should be prioritized for vaccination as a feasible and effective way to limit the spread of PRRS. To this end, increased farmer awareness and improved overall surveillance by veterinarians and other animal health workers is necessary.

A supplementary study from Vietnam used national surveillance data to reveal seasonal patterns and space-time clusters of the disease (21). The findings provide policy makers with necessary insights on critical areas and timing of outbreaks, thus identifying when and where national surveillance and control programs could be implemented most efficiently. Again, to prevent outbreaks and onward transmission of PRRS it is important to raise farmer awareness on vaccination in high-risk areas.

African swine fever

African swine fever (ASF) is a highly contagious viral disease of pigs which is responsible for serious production disturbances worldwide. Domestic pigs are generally infected through direct transmission of the virus, however, there is also a sylvatic cycle involving wild porcines and soft ticks. In a study from Tanzania (56) 18 % of sampled *Ornithodoros* ticks were carrying ASF virus of genotype XV, and as many as 84 % of 19 tested warthogs were found to have been exposed to the virus. These results suggest that domestic pigs may be at risk of contracting ASF if reared in areas where wild porcines are prevalent.

In non-endemic areas the disease is controlled primarily by means of appropriate import regulations, animal movement control and strict biosecurity measures. In Vietnam, where ASF was first reported as late as in 2019, there is a need to establish science-based prevention and control programs where simulation models could be a critical tool. Within Cluster 1 two studies were performed using stochastic simulation principles (52, 53) and the results provided evidence and confirmed that enforced movement restriction was an effective control measure when an outbreak was reported, and that high standards of biosecurity can contribute to reduction of disease spread. It was concluded that simulation models for infectious diseases have the potential to be

important tools for decision-makers to evaluate the impact of outbreaks and to identify cost-effective control strategies.

Foot and mouth disease

One study to assess timing and hotspot areas of FMD outbreaks was executed in Vietnam where this infection is endemic (31). No nationwide investigations of this kind had previously been conducted and thus this study provides useful information to policymakers on which livestock species that are most frequently involved in outbreaks, as well as temporal patterns and space-time clusters of outbreaks. This study is a good example of how retrospective epidemiological investigations can suggest where and when national surveillance and control programs could be implemented for the prevention and control of FMD.

Respiratory disease

Using participatory methods with smallholder farmers in Ethiopia, respiratory disorders were highlighted by the farmers as being one of the most significant health constraints perceived in small ruminants (18). Lungworms are well known as responsible for pneumonic lesions and studies in Ethiopia (10) as well as Tunisia (4) confirmed that lungworms of several species are prevalent in both countries in small ruminants.

Respiratory disease is also a common problem in pigs in Africa, as reviewed (34). Pneumonic lesions had a high prevalence in slaughtered pigs studied in Uganda (54). Pigs that were infected with *Metastrongylus* lungworms and *Ascaris* roundworms were more likely to be coinfecting also with bacterial or viral pulmonary pathogens (55). Farms with poor hygiene and drainage showed a higher likelihood of respiratory infections. The study thus showed, not surprisingly, that improved hygiene and biosecurity is critical for the reduction of pneumonic pathogens in pig farms.

Zoonotic infections

The risk of transmission of zoonotic infections between animals and humans is an issue that has received increasing consideration, not least in light of the ongoing coronavirus pandemic which most likely has an animal origin. Generally speaking, apart from a few well-known viral infections there are a number of zoonotic infections that have not received as much attention, particularly not so in low-income countries. Some of these less conspicuous infective agents have been subject to studies within Cluster 1, both directly and indirectly, and a One Health perspective is advocated (37).

In a study in pigs in Vietnam (33) more than half of the investigated animals were found infected with Hepatitis E virus including the zoonotic genotypes 3 and 4. In another study from northern Vietnam (32) high seroprevalence rates were found with Japanese

encephalitis and *Leptospira* infection. It was concluded that from a public health point of view, it is important to raise public awareness of the risks connected with these kinds of infection especially for high-risk groups like farmers and their families and pig farm and slaughterhouse workers and others who have probabilities to come in contact with live pigs and contaminated meat.

In a study on abortion in small ruminants in Ethiopia annual abortion rates of 16 and 13 % were found in investigated flocks of goats and sheep, respectively (44). A number of abortifacive agents in small ruminants are known zoonotic and thus pose a potential threat to female farmers in particular and therefore call for special attention. This is true for the protozoan parasite *Toxoplasma gondii* and species of the bacterial genera *Brucella*, *Chlamydia* and *Coxiella*. When the prevalence of these agents was studied in sheep and goats in Ethiopia it was found that a large majority of tested animals had antibodies to one or more of these agents and coinfections were common (44). It was suggested that many abortions had a multifactorial background that requires an integrated approach involving nutritional and management considerations and application of appropriate biosecurity practices. 18-58 % of the sheep and goat flocks under study had experienced abortions during the year before onset of the study, which means that reproductive failure is widespread and its causes deserve systematic attention.

A related study in Ethiopia on knowledge, attitudes and practices (KAP) on zoonotic risks from livestock birth products among farmers (45) revealed substantial knowledge gaps and high-risk behavioral practices concerning transmission of zoonotic agents from birth products. However, no concluding data seems as yet to be available on the incidence or prevalence of these kinds of zoonoses in humans in Ethiopia.

Cysticercosis caused by the human tapeworm *Taenia solium* is a classical parasitic zoonosis that deserves continuous attention in the African situation (27). Based on a seroprevalence rate of more than 10 % in pigs in northern Uganda (20) it was concluded that an 'awareness campaign' together with prevention and control measures would be necessary to minimize the risk of transmission of the parasite to pork consumers in endemic areas.

Gender

An important aspect of smallholder animal production, particularly in Africa but also in e.g. Vietnam, is that women usually have the main responsibility for practical management and care of the family's livestock, in particular the smaller species. This means that women need to be actively involved in the planning of measures to prevent and control livestock diseases, and their experiences need to be taken into account when planning animal health interventions. For the implementation of biosecurity measures, for example in relation to ASF prevention, a better understanding of the gender dimension will improve disease control measures. It is stated that the need to systematically counteract unproductive gendered perceptions and practices cannot be overemphasized (26). It is also important that information concerning risks connected

with animal diseases, zoonoses in particular, need to be communicated to women as they and their children may be the ones primarily at risk of contracting such infections (14, 45).



The role of women in animal husbandry is frequently overlooked, even though women are often caretakers of animals in the homestead. Improving their access to animal health services and training can play a big role in contributing to greater animal productivity. Photo ILRI/Kabir Dhanji

Gender considerations are commonplace in Cluster 1 publications and some of the papers also have addressed gender issues specifically in studies where farmer household members have been subject to interviews and focus group discussions to clarify their knowledge and attitudes in relation to livestock management and disease control (5, 14, 17, 26, 28, 45). It is demonstrated that animal diseases impact the food security of women in particular and thus gender considerations should be included by research institutes and donors when prioritizing research on animal management and health interventions (5, 14). However, the perceptions and priorities by men and women may also be very similar, and both need to be involved in designing health management interventions (28). No doubt the understanding of who does what in a farmer's household opens important entry points to target future interventions related to disease control (17).

Modelling

A significant part of the Cluster work has been to provide and utilize assessment tools to study animal health constraints and control options. To this end predictive or simulation models were adopted as were models that show which control methods to prioritize, including farm biosecurity measures. Especially the work in Vietnam has proved useful for predicting outbreaks of livestock diseases such as FMD (31) and ASF (52, 53) or for suggesting preventive measures, for example with PRRS (21, 22). This information has

been embraced by the national authorities in Vietnam and also been published at governmental websites.

The spread of PRRS virus was also studied in Uganda by simulation modelling (50) that would potentially provide insights to the national government on how PRRS can be prevented and controlled by means of vaccination and different biosecurity measures.

Disease priorities

There has been a tendency for researchers and donors to primarily engage in well-known diseases that are unambiguous and well-defined and that already appear in or risk spreading to high-income countries. In a review paper on respiratory pathogens in pigs in Africa (34) it is concluded that most national surveillance systems focus on single diseases instead of undertaking a more holistic approach that would provide better insights in how to target animal health interventions. One purpose with the Cluster work has thus been to survey the prevalence and significance of other less conspicuous diseases in pigs and small ruminants, respectively (49).

In an ILRI report (23) a set of tools are presented that support objective decision making on what disease constraints need to be targeted by interventions. Female and male farmers' perception and experience of animal diseases were studied by means of 'participatory epidemiology' in Ethiopia showing the importance of the farmers' involvement when discussing research priorities and designing health management interventions (28).

Based on surveys of a number of infectious agents in small-scale pig systems in Uganda (13) and Vietnam (32) and small ruminants in Ethiopia (18), a set of pathogens could be mapped as a basis for future interventions. It was stated that the priorities of the national disease control programs do not fully match the priorities of farmers, and it was suggested that participatory tools therefore should play a pivotal role when designing sustainable livestock health interventions (18).

Economic effects

Animal diseases have both social and economic impacts in smallholder communities, but the effects are difficult to quantify in societies where subsistence farming and informal economics have a significant place. A few Cluster 1 related papers discuss the conditions for quantitative assessment of social and economic impact of livestock diseases (3, 7, 8, 29, 35) but a general conclusion may be that tools to systematically determine the socio-economic burden of animal diseases in smallholder communities is as yet not available (29).



The kitchen in a pork joint (restaurant) in Kampala, Uganda. The pig sector in Uganda provides income for the approximately two million people who work along the pig value chain. Photo ILRI/Kabir Dhanji

Impact

The work within CRP Livestock and its Flagships has no doubt been a huge undertaking and likely a lot of non-documented positive impact has been achieved through the work with partners, regional and national authorities and even ministries and with that raised awareness of diseases that tend to be ignored in control programs. During a study visit to Uganda in 2019 I could personally witness the good personal relationships that were established with individuals at the government level and the interest they showed in taking part of results of the CRP studies.

It is clear that the devastating Covid-19 pandemic has seriously undermined the possibilities to carry out both field and lab work during the concluding at least eighteen months of the CRP– which equals to more than one fourth of the time allocated for this five-year program. Against this background it is difficult to make assessments as to what extent results and recommendations have been adopted by national and regional authorities and decision-makers, and if any changes can be seen in the distribution of resources for disease control in the priority countries. Drs. Wieland, Dione and Lee were asked to give their views on the impact obtained by the Cluster 1 activities, and their impressions and thoughts are used in the following text where appropriate.

Dr. Wieland agrees that in the short time since the publication and dissemination of results, it is difficult to have firm evidence of any obvious impact from the Cluster work and of shifts in budget allocated to different diseases at government level. She still wants to emphasize, however, that “in particular in Uganda and Ethiopia diseases that previously would never come up in discussions are now topics that veterinarians and

authorities talk about. This is also reflected in discussions about the need to improve access to veterinary services and veterinary medicines and the need for herd health solutions. There are various stakeholders profiting from the evidence generated, for example the farmers themselves who were involved in the studies, the veterinarians who now better understand that a broader spectrum of diseases are important, the extension officers who learnt a lot in the process, and the authorities and veterinary bodies who now have more arguments at hand to stress the importance of also diseases other than the familiar ones.”

“Another important change observed by the teams is that thanks to utilizing specific gender sensitive tools, the way women's role in animal husbandry is discussed is changing and acceptance that livestock diseases affect household members differently has become very clear and an argument made by organizations that in the past did not bring in gender at all.” (B. Wieland).

Both Dr. Wieland and Dr. Dione emphasize the extensive work performed on the epidemiology and control of PPR (the ECo-PPR project) including the socio-economic impact of the disease. “The ECo-PPR toolbox is already being implemented in more than six countries in Africa (Senegal, Mali, Burkina Faso, Ethiopia, Kenya and Tanzania) with the same approaches used in Uganda in the PPR BUILD¹ project. OIE/FAO and other international partners are closely following the results generated from the ECo-PPR project and thus the tools likely will be taken up by further countries in the future.” (B. Wieland).

Dr. Lee, leading the Cluster activities in Vietnam, points out that their papers have been posted through the website of the Ministry of Agriculture and Rural Development in Vietnam (MARD) and that they are also shared with the Central Government (Department of Animal Health and the National Institute of Veterinary Research). Some of the risk maps for ASF were shared with the regional authorities where the hotspots were identified. As a result, one of the regions is trying to mobilize internal funds for further epidemiological investigations and exploring possible control measures concerning ASF. “We developed a disease modelling tool (including a survey tool and simulation model) in Vietnam which was already applied to Uganda. We believe that this approach can be used for other diseases and evaluation of possible control interventions in the future.” (H.S. Lee).

“However, the capacity and understanding of veterinary epidemiology is generally poor in the countries where we have worked. In addition, the communication and sharing of information between researchers and policymakers are often lacking. So evidence-based disease control and prevention strategies have not been properly implemented previously. I believe that our achievements can be helpful for policymakers to understand how our findings can be used for decision-making. Indeed, the risk maps for FMD and PRRS using the national surveillance data and the simulation modelling approach with PRRS and ASF were found very useful by the central government in

¹ Boosting Uganda's investment in livestock development

Vietnam. Representatives for the Vietnamese government has expressed a strong ambition to continue working with ILRI teams in the future. (H.S. Lee).

Dr. Wieland concludes that “The work in Cluster 1 has generated evidence on disease occurrence of previously neglected diseases in research projects. The work provided evidence and examples of good practice on how to measure impact of the diseases. Indeed the mix of qualitative and quantitative data has been key and should be recommended in the future.” And Dr Lee adds that “the results of the Cluster research no doubt has an impact on the attitude of stakeholders on how this science can be translated into policies. Our analysis and approach can be useful for the national disease prevention and control programs as well for the change of attitudes and the way of thinking.”

Conclusions

Overall, the work performed within the Cluster is of high scientific quality and focuses commendably on diseases and issues that are both relevant and timely.

One criticism that can be leveled at some parts of the output is that, despite the Cluster's pronounced focus on defined topics and livestock species, some fragmentation appears to take place with research studies performed without obvious contact with other cluster work and with the CRP in general. Some of the publications thus give the impression of being random contributions to the investigation of the disease panorama in a given country. Further, authors of a number of publications that can be assumed to be linked to the Cluster have failed to acknowledge the CRP, which is unfortunate as it is important to highlight the context in which the research is conducted. The CRP Livestock and its Flagships – and donors – are worthy of all attention they can get.

Having said this, the work and achievements of the Cluster deserve great respect. The dedication that has been put into the Cluster activities and the professionalism shown by researchers, students and management is impressive.

Among achievements and deliverables that particularly deserve to be highlighted are:

- The pronounced focus on smallholder animal production and the role of livestock for poverty reduction and food security that has permeated the work of the Cluster. This is a basic theme for the studies throughout this CRP and as such a highly relevant principle.
- The consistent recognition of women's crucial role in the management and care of the family's livestock and in disease control. From this follows the importance of involving women in the planning of measures to prevent and control animal diseases and to listening to and taking advantage of their experiences.
- The ECo-PPR toolbox and other resources that have been developed to support the FAO/OIE global eradication program for PPR by 2030. Probably the single most

important achievement within the Cluster 1 activities that has also involved other clusters of FLH.

- The establishment of modelling tools to predict disease outbreaks and evaluate the effects of intervention measures. These are examples of modern and practically oriented epidemiology research and development which is indispensable for the provision of evidence-based advice on prevention and control of livestock diseases.
- The focus on risk management with new aspects of how to utilize national surveillance data for developing risk maps and simulation models where livestock handling and farm biosecurity are key components.
- The surveys and mapping of infectious diseases other than the most conspicuous, and the insight that no infection occurs in isolation but in combination with other agents and during particular management conditions.
- The provision of insights on a number of relevant zoonotic pathogens where awareness and information on hygiene measures are crucial in order to make livestock production safer. This is not least important for the women who often are most at risk due to their involvement in birth assistance and management of aborted fetuses, but also in cooking and the handling of milk and raw meat.
- The inclusion of economic and socio-economic considerations on the animal health issues under study, as well as the application of a One Health approach in a broader sense than commonly used where human health is not only potentially affected by zoonotic pathogens, but also where the health and wellbeing of man is influenced by management factors and livestock diseases that are not necessarily directly transmissible to humans.
- The strategic investments in critical reviews in relevant areas. These are important for knowledge development and planning of future research, and make the operating researcher/s known in the science community.
- The active inclusion of national and international MSc and PhD students in much of the field and lab work is commendable. By this the CRP has provided additional impact by contributing to the long-term building of epidemiology and other research capacity in the countries involved.
- The efforts to actively establish contact not only with farmers and their communities but also with regional and national authorities and governments to anchor the results and ensure that they come into practical use in control programs.

As a final recommendation, it appears sensible that the efforts and activities that have now been initiated within the CRP will have the opportunity to continue develop in one or another format. This applies in particular to the work that focuses on risk analysis, modelling of disease epidemiology and control, the effect of gender, and the delivery of animal health services. It seems reasonable that the interruption in the work caused by Covid-19 can be compensated by an extension of the program.

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Dr. Michel Dione, Dr. Hu Suk Lee and Dr. Barbara Wieland are warmly thanked for providing valuable inputs and personal reflections, and Prof. Ulf Magnusson for constructive advice and comments throughout the work on this survey.

Abbreviations

ASF	African swine fever
CGIAR	A global research partnership for a food secure future dedicated to reducing poverty, enhancing food and nutrition security, and improving natural resources.
CRP	CGIAR Research Program
FLH	Flagship livestock health of the CRP on Livestock
FMD	Foot and mouth disease
ICARDA	The International Center for Agricultural Research in the Dry Areas
ILRI	International Livestock Research Institute
MARLO	Managing Agricultural Research for Learning and Outcomes
PPR	<i>Peste des petits ruminants</i>
PRRS	Porcine reproductive and respiratory syndrome
SLU	Swedish University of Agricultural Sciences

Appendix 1

Cluster 1 list of publications, retrieved from MARLO 30-09-2021

2017

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Appendix 2

Terms of reference for survey of Cluster 1 in the Flagship Livestock Health of CRP Livestock

12 May 2021

Background

The CGIAR research program CPR Livestock Agri-food Systems, running from 2016 to 2021, is coming to an end. The Animal Health flagship of the CRP has aimed to develop and implement new approaches to reduced livestock disease risks associated with intensification and climate change and closed yield gaps through improved animal husbandry practices.

The Cluster 1 in the flagship (**Evaluate animal health constraints and threats**) aims to develop and deploy methods and tools that could be used in low-income countries to identify the extent and impact (on animal productivity and farmers' livelihoods) of animal health constraints. The cluster 1 commits to deliver two "products lines":

Product line 1: Assessment tools for significance of animal diseases

The Cluster 1 has developed tools to prioritize diseases in different livestock systems including pigs, small ruminants and cattle were.

Product line 2: Risk models and maps for animal diseases

The Cluster 1 has developed risk assessment tools and implemented studies on risks of emerging diseases such as African swine fever (ASF), Foot-and-mouth disease (FMD), Porcine reproductive and respiratory syndrome (PRRS). New modelling approaches, such as those based on complex systems theory and emergent properties of systems, were used to systematically assess the biophysical and socio-economic impact of livestock diseases, to inform development of interventions.

Aim of consultancy

The aim of the consultancy is to compile a synthesis report of the disease prioritization tools and assess how/if they have influenced disease control in target countries. The consultant will also produce a draft text for a policy brief. The consultant will be provided materials from scientists in the cluster and conduct interviews when appropriate, such as inventory of knowledge generated under Cluster 1 (papers, reports, briefs) and evidence of uptake: who has accessed this, how has it been received.

Foreseen deliverables

1. Synthesis report giving an overview of the methodologies and elaborations and lessons learned on tool development and their uptake. How can this inform tool development in the future?
2. Draft text to a brief report

Contact person within CRP Livestock/Flagship Animal Health/Cluster 1: Dr. Michel Dione