RESEARCH PROGRAM ON Livestock and Fish

Brief 16

More meat, milk and fish by and for the poor

December 2016

Assessing the environmental impacts of livestock and fish production

An Notenbaert (CIAT), Malcolm Dickson (World Fish), Rein van der Hoek (CIAT) and Patrik J.G. Henriksson (WorldFish)

The challenge

While livestock production has for some time been linked to deforestation, land degradation, biodiversity loss and water scarcity, more recent studies, and particularly the publication of the 2006 FAO report 'Livestock's long shadow' indicate that livestock is also a significant source of greenhouse gas (GHG) emissions (Steinfeld et al. 2006). The follow-up 2013 FAO report, 'Tackling climate change through livestock' estimated that livestock was responsible for 14.5% of all anthropogenic GHG emissions, including 5% of anthropogenic carbon dioxide, 44% of anthropogenic methane and 55% of anthropogenic nitrous oxide (Gerber et al. 2013). As demand for livestock products continues to grow, driven by rising population and dietary shifts, there is an urgent need to develop strategies to reduce the environmental footprints and GHG emission intensity from livestock. The first step in this process is to develop tools to estimate potential impacts of such strategies.

The situation is slightly different for fish as there is less knowledge on the magnitude of the environmental impact of these systems. Until recently, the main aquaculture-related threats were considered to be genetic contamination or displacement of wild stocks due to farmed fish escapes, the transfer of disease from farmed to wild stocks, eutrophication of aquatic ecosystems caused by fish farm discharges, pressure on wild fisheries for fish meal and the destruction of wetlands or coastal ecosystems due to aquaculture development. However, recent studies (Henriksson et al. 2017; Henriksson et al. 2015; Nhu et al. 2016) have recognized the wider environmental footprint of aquaculture, including GHG emissions, which needs to be ascertained and its impact mitigated as production expands.

In short, the aquaculture sector needs to speak the same environmental impact language as other agricultural production sectors.

Pathways to impact

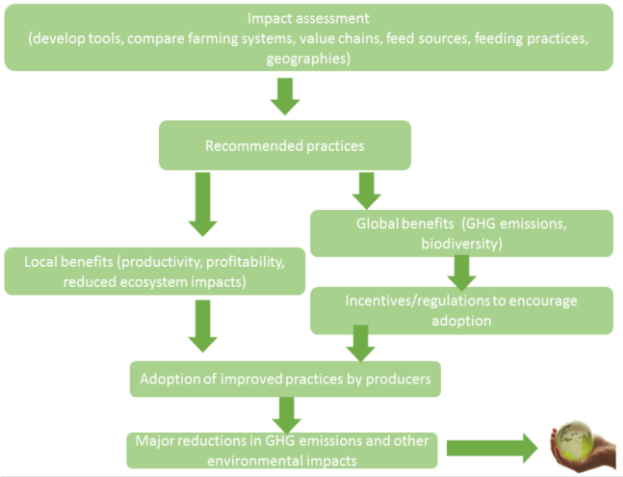
National governments and other stakeholders have recognized that livestock, and to some extent aquaculture, have significant environmental footprints. One way of reducing impacts would be to cut consumption of livestock and aquaculture products. However, these sectors make a valuable welfare contributions in many economies. Reduced consumption could threaten the livelihoods of vulnerable producers and value chain actors, as well as the nutrition security of large populations, in the developing world. A more attractive and achievable option would be to improve the resource-use efficiency of livestock and aquaculture practices which is believed would result in rapid environmental gains.

The first step in this process is to develop tools to estimate and model potential impacts of improved livestock and fish practices along value chains. Results of the assessments carried out by the Program in Egypt, Nicaragua and Tanzania show that there are clearly identifiable win–win scenarios where immediate benefits, such as increased productivity, incomes and ecosystem services, such as soil fertility, water availability and biodiversity, can incentivize farmers to adopt improved practices and technologies, while reducing environmental impacts.

In addition, evidence created through impact assessment at the local farm and landscape levels can be extrapolated and used to design national and regional incentive schemes or regulatory frameworks to ensure appropriate governance mechanisms and significant investment at this level (see Figure 1).

The need for more detailed understanding of environmental impact of livestock and fish production needs to be highlighted, potential gains communicated and integrated into policy frameworks at different levels.

Figure 1: Pathways to impact



Processes to target for engagement include the Sustainable Development Goals where member states are expected to translate global goals into national targets. Signatories to the United Nations Framework Convention on Climate Change (UNFCCC) published documents outlining their Intended Nationally Determined Contributions (INDCs) for GHG emission reductions in preparation for the 2015 UN Climate Change Conference in Paris. After ratification of the Paris Agreement, INDCs are being converted to nationally determined contributions—with GHG targets under the UNFCCC applying to both developed and developing countries. Many INDCs include cuts in GHG emissions by agriculture. However, aquaculture is rarely mentioned, usually just as a mitigation measure to offset climate change impacts on fisheries.

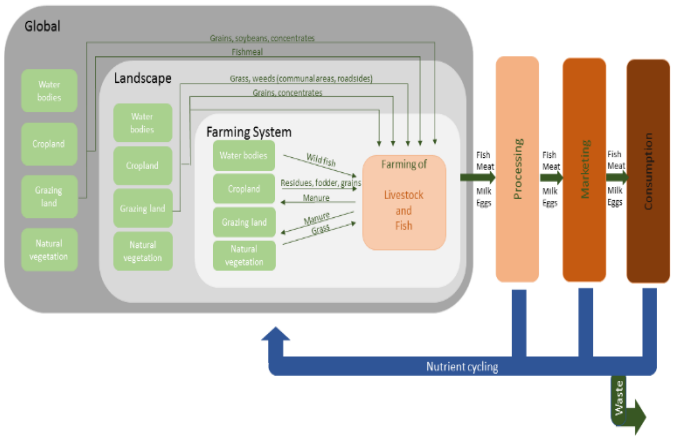
Environmental assessments

The Livestock and Fish CGIAR Research Program (CRP) proposal aimed to increase production in key animal-source food value chains, while also including a sustainability objective to 'protect the natural resource base and its ability to continue providing ecosystem services'. One of the planned activities included carrying out 'life cycle analysis of livestock and fish production and marketing to evaluate carbon footprint, environment and resource implications and demands'.

This led to the development of tools by ILRI, CIAT and partners (CSIRO and SEI) to estimate environmental impacts of livestock value chains under the CLEANED project[1], using two types of software: Excel (CLEANED^{X}) and R (CLEANED^{R}). It was mainly developed and tested with dairy value chains in Tanzania and Nicaragua. In Egypt and Bangladesh, WorldFish partnered with the Stockholm Resilience Centre to carry out life cycle analysis (LCA) of pond-based tilapia systems and carp polyculture systems.

Both efforts undertook environmental multi-dimensional environmental assessments with a value chain perspective. The main stocks and flows taken into account include land, nutrients, biomass and waste (figure 2), with the different stocks, flows, processes and interactions taking place at different scales.

Figure 2: Main stocks and flows taken into account in the environmental assessments



Lessons learned

Although the two approaches—with their associated tools and databases—have quite distinct strengths and weaknesses (table 1), they were both able to compare the impacts of promising scenarios, quantify environmental impacts and identify entry points for eco-efficient livestock and fish production.

The main difference between them is that CLEANED is limited to aquaculture and livestock. The number of processes included in the inventory model also sets the two frameworks apart, with CLEANED limited to the grow-out phase and feeds, while LCA takes a wide range of processes into account, generally including burning of fossil fuels, electricity generation, fertilizer production, infrastructure, etc. The CLEANED framework is, currently, more geographically specific than most LCAs, so it may be more useful for *ex-ante* assessments and regional planning.

The CLEANED tools suit participatory, local estimates of environmental impacts where there are clear boundaries and integrated activities at a location—for example, a small farm using locally-grown materials to feed livestock. The LCA approach is more suited to situations where inputs—such as feeds—and impacts extend beyond farm boundaries.

1 CLEANED was a pilot project supported by the Bill & Melinda Gates Foundation to produce a Comprehensive Livestock Environmental Assessment for Improved Nutrition, a Secured Environment and Sustainable Development along Value Chains.

Table 1: Characteristics of the CLEANED and LCA tools

	CLEANED^X	CLEANED^R	LCA
Application	Extensive and semi-intensive livestock	Extensive and semi-intensive livestock	Any economic product
Vertical coverage	Farm-site; waste along the value chain	Animal production and onsite inputs; waste along the value chain	From extraction of raw materials to farm-gate, market or landfill.
Impacts scaled to:	Farm enterprise and animal product	Pixel on regional map	Functional unit
Geographically explicit?	No	Yes	No
Considering off-site impacts	No	No	Yes
Considers ecosystem carrying capacity	For soil and (water)	For water and soils	
Level of parameterization	Medium	Low for Africa	High
Available software	Excel sheet	R code	Several, but many are costly
Databases	Feedipedia FEAST IPCC	Feedipedia FEAST GAEZ IUCN IPCC	Several, but many are costly
Impact categories	GHGs, soil health, (water)	GHGs, soil health, water use intensity and biodiversity.	Global warming, acidification, eutrophication, water use, land use, biodiversity loss, etc.
Accounts for uncertainties	Not possible	Not possible	Possible

Applying the CLEANED and LCA frameworks in different countries and value chains has shown there are clearly identifiable environmental co-benefits of increasing livestock and fish productivity. It also shows that synergies with profitability, labour reduction and food and nutrition security etc. are possible when additional cost-benefit or wider socio-economic assessments, are combined with environmental assessments. While environmental assessments themselves are useful and interesting, they would be even more powerful when carried out alongside non-environmental assessments.

In both assessments of CLEANED for livestock and LCAs of fish, feed inputs emerge as the most critical area where environmental costs are currently incurred and where considerable efficiency gains can be obtained.

By providing comprehensive and reliable information, the assessments aim to contribute to sustainable livestock and fish value chain development. To ensure that the results and insights of the assessments are taken up and contribute to more-informed planning, it is important to integrate them in decision-making processes through early involvement of stakeholders. This raises awareness, creates support for the issue and its solutions, and increases the likelihood of the recommendations being implemented. Engagement in the evidence-generating process is often at least as important as the actual information produced.

The results of these policy and institutional assessments need to provide both local and national incentives for widespread adoption of sound environmental management. It would, therefore, be useful to connect the CLEANED and LCA activities with other related initiatives in the sector such as the Global Livestock Environmental Assessment Model[2].

Next steps

The Livestock and Fish CRP will be replaced by two new CRPs; one on livestock led by ILRI and one on fish led by WorldFish. The livestock CRP flagship on Livestock and Environment plans to assess two-way interactions between the environment and productivity-improving technologies and, to this end, the CLEANED tools will be further refined and developed to include cost-benefit calculations and off-site feed impacts. The fish CRP envisions that 'life cycle analysis and foresight modelling will provide insights into the social and environmental implications of aquaculture growth'.

Both CRPs can build on these experiences to validate, ground-truth and refine these models. They can then apply the most appropriate tools to compare the impacts of promising intervention scenarios (such as genetic improvement, improved feeds and feeding systems, improved land use, reduced losses in the value chain) in terms of soil health, water use and quality, biodiversity and GHG emissions and, as such, complement wider socio-economic assessments.

This should be carried out in close collaboration with governments, development organizations, private sector partners, etc., to allow for the out- and up-scaling of context-specific recommendations.

[2] http://www.fao.org/gleam

References

- Gerber, P.J., et al. 2013. *Tackling climate change through livestock: A global assessment of emissions and mitigation opportunities*. Rome, Italy: FAO. www.fao.org/docrep/018/i3437e/i3437e00.htm
- Henriksson, P.J.G., et al. 2017. Benchmarking the environmental performance of best management practice and genetic improvements in Egyptian aquaculture using life cycle assessment. *Aquaculture* 468(1):53–59. dx.doi.org/10.1016/j.aquaculture.2016.09.051
- Henriksson, P.J.G. et al. 2015. Comparison of Asian aquaculture products by use of statistically supported life cycle assessment. *Environmental Science and Technology* 49(24): 14176-14183. dx.doi.org/10.1021/acs.est.5b04634
- Nhu, T.T. et al. 2016. Environmental impact of non-certified versus certified (ASC) intensive Pangasius aquaculture in Vietnam, a comparison based on a statistically supported LCA. *Environmental Pollution* 219: 156-165. dx.doi.org/10.1016/j.envpol.2016.10.006
- Steinfeld, H., et al. 2006. *Livestock's long shadow: Environmental issues and options*. Rome, Italy: FAO. www.fao.org/docrep/010/a0701e/a0701e00.htm

Credits and more information

This brief was produced as part of a synthesis activity of the CGIAR Research Program on Livestock and Fish. It focuses on *ex-ante* environment impact assessment work carried out between 2012 and 2016 and supported by the Program and other investors. Briefs in this series are:

- Notenbaert, A.M.O., Dickson, M., Hoek, R. van der. and Henriksson, P. 2016. *Assessing the environmental impacts of livestock and fish production*. Livestock and Fish brief 16. Nairobi: ILRI. http://hdl.handle.net/10568/78478
- Notenbaert, A.M.O., Lannerstad, M., Barron, J., Paul, B., Ran, Y., Morris, J., Fraval, S., Mugatha, S. and Herrero, M. 2016. *Using the CLEANED approach to assess the environmental impacts of livestock production*. Livestock and Fish brief 17. Nairobi: ILRI. http://hdl.handle.net/10568/78476
- Pfeifer, C., Morris, J. and Lannerstad, M. 2016. *The CLEANED R simulation tool to assess the environmental impacts of livestock production*. Livestock and Fish brief 18. Nairobi: ILRI. http://hdl.handle.net/10568/784764
- Birnholz, C., Paul B. and Notenbaert A.M.O. 2016. *The CLEANED Excel tool to assess the environmental impacts of livestock production*. Livestock and Fish brief 19. Nairobi: ILRI. http://hdl.handle.net/10568/78472
- Hoek, R. van der., Birnholz, C. and Notenbaert A.M.O. 2016. *Using the CLEANED approach to assess environmental impacts in the dual-purpose cattle value chain in Nicaragua*. Livestock and Fish brief 20. Nairobi: ILRI. http://hdl.handle.net/10568/78473
- Notenbaert, A.M.O., Morris, J., Pfeifer, C., Paul, B., Birnholz, C., Fraval, S., Lannerstad, M., Herrero, M. and Omore, A.O. 2016. *Using the CLEANED approach to assess environmental impacts in the dairy value chain in Tanga, Tanzania*. Livestock and Fish brief 21. Nairobi: ILRI. http://hdl.handle.net/10568/78475
- Henriksson, P. and Dickson, M. 2016. *Using the life cycle assessment approach to assess the environmental impacts of fish production*. Livestock and Fish brief 22. Nairobi: ILRI. http://hdl.handle.net/10568/78471
- Dickson, M. and Henriksson, P. 2016. *A life cycle assessment of the environmental impacts in the Egyptian aquaculture value chain*. Livestock and Fish brief 23. Nairobi: ILRI. http://hdl.handle.net/10568/78478

The program thanks all donors and organizations which globally support its work through their contributions to the CGIAR system

Patron: Professor Peter C Doherty AC, FAA, FRS

Animal scientist, Nobel Prize Laureate for Physiology or Medicine–1996

Box 30709, Nairobi 00100 Kenya
Phone +254 20 422 3000
Fax +254 20 422 3001
Email ilri-kenya@cgiar.org

ilri.org
better lives through livestock

ILRI is a CGIAR research centre

Box 5689, Addis Ababa, Ethiopia
Phone +251 11 617 2000
Fax +251 11 667 6923
Email ilri-ethiopia@cgiar.org

ILRI has offices in East Africa • South Asia • Southeast and East Asia • Southern Africa • West Africa

December 2016