Food and Agriculture Organization of the United Nations

Livestock Investment Coordination System:

Livestock Investment Rapid Appraisal tool

Rationale and goal

Driven by climate change, natural disasters are increasing in frequency and scale while progress towards the Sustainable Development Goals appears to have slowed down or even reversed in some parts of the world. At the same time, food insecurity is on the rise. Many of the most vulnerable population groups rely at least partially on livestock for their livelihoods. Keeping livestock can enhance resilience and, due to growth in demand for animal-source food in low- and middle-income countries, livestock sector development offers livelihoods opportunities for rural communities. Thus, livestock initiatives represent an opportunity for programming across the triple nexus, i.e. to address the interconnected challenges of humanitarian crises, development and conflict prevention.

There is a high demand from governments, Food and Agriculture Organization of the United Nations (FAO) Country Offices, plus humanitarian and development partners for better coordination of livestock sector assistance. With the support of the Bill and Melinda Gates Foundation, FAO is developing the Livestock Investment Coordination System (LICS) to improve planning, monitoring and evaluation of livestock interventions for use by FAO as well as by interested partners. The Livestock Investment Rapid Appraisal (LIRA) tool is one of the tools being developed under the LICS. It is intended to provide a simple, web-based tool for a rapid ex-ante appraisal of investment options to address a wide range of acute or chronic constraints to livestock production. Its aim is to support more rational consideration of options rather than to provide precise economic/financial investment metrics. To this end, LIRA strives to provide the ability to address livelihoods, food security, gender, environmental, public health and other selected outcomes. The tool aims to be useful in contexts with minimal information and expertise but to offer the possibility of expansion and greater complexity as additional information becomes available.

LIRA consists of three core elements:

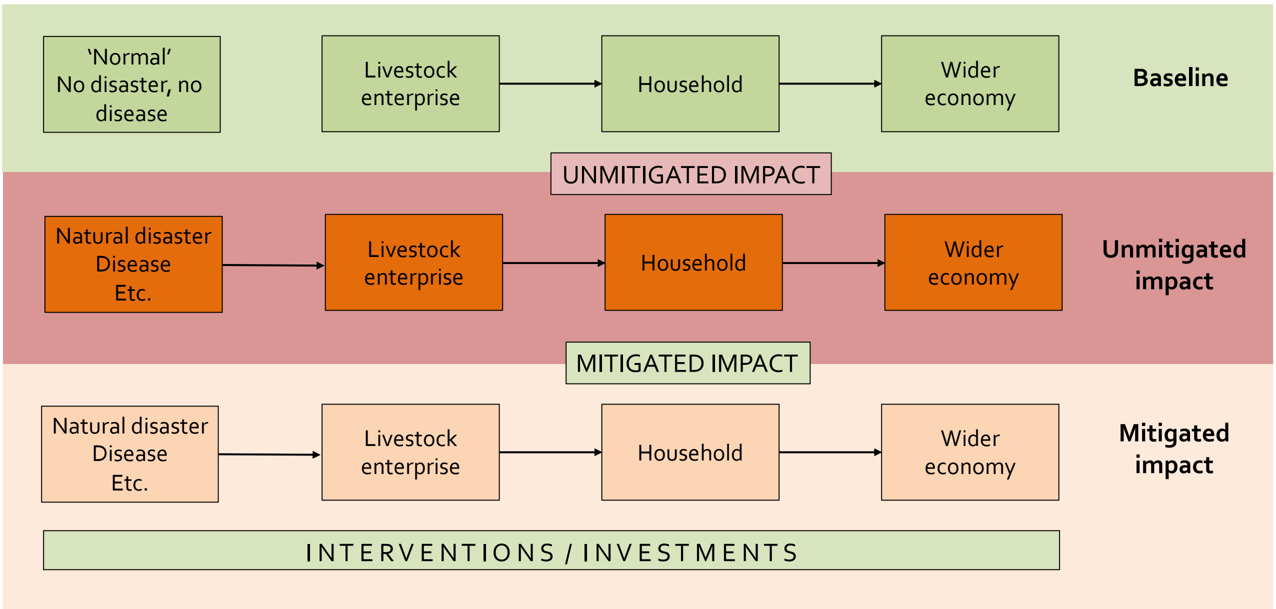
1. A standardized approach for the ex-ante appraisal of livestock interventions, developed and tested in collaboration with humanitarian and development actors;
2. Data repositories of (i) region and production system-specific production parameters that permit the rapid generation of baselines, (ii) the direct production impact of hazards of interest on livestock production (i.e. epidemic and endemic diseases, extreme weather events, nutritional deficiencies, etc.) and (iii) anticipated cost and effectiveness of potential interventions; and
3. An easily accessible online application taking users through computations offering default parameter values with the option of changing them and experimenting with alternatives.

The development of LIRA is foreseen as an iterative process underpinned by a community of practice providing feedback and inputs in the process of applying the tool.

Approach

The rapid investment appraisal builds on the comparison of a baseline scenario with a hypothetical scenario, in which no measures are taken to mitigate the impact of a hazard on the livestock population of interest, resulting in an estimate of the unmitigated impact at the livestock enterprise level. In situations where information is available on household assets and incomes, the unmitigated impact on a specific livestock enterprise can be traced through the household economy to estimate the unmitigated household-level impact[1]. Subsequently, a second analysis is performed to assess the expected reduction of the unmitigated impact through potential interventions/investments, giving rise to an estimate of the mitigated impact of the selected hazard on the livestock (and human) population(s) of interest. This approach is schematically represented in Figure 1.

Figure 1. Schematic representation of the proposed approach for the rapid appraisal



of livestock interventions/investments

The 'normal' production and population dynamics of the livestock population of interest, i.e. the baseline, is constructed by means of a dynamic bio-economic herd model using local (production system- and region-specific) production parameter values, compiled from the literature and expert opinion, and farm gate prices. Farm gate prices can either be obtained from national price databases or need to be specifically collected. Estimation of the unmitigated impact of the selected hazard on an affected herd/flock draws on reported impacts of the hazard on key production parameters such as mortality, milk yield, growth rate, etc., and possibly price effects. Subsequently, the mitigated impact is estimated using expert opinion/experience of the expected success of the considered mitigation intervention(s) on a herd/flock exposed to the hazard. The product of the difference between mitigated and unmitigated impact and the likelihood of hazard exposure is considered the intervention benefit. The latter is then related to the cost of the intervention (financial and other) to generate diverse cost-effectiveness metrics

[1] A still broader appraisal might consider estimating unmitigated economy-wide impacts using LIRA output as input for a partial equilibrium model.

(e.g. benefit-cost ratio [BCR], break-even investment per animal, break-even disease risk[2], etc.). Given the high uncertainty of most of the information needed to estimate benefits and costs of selected interventions, these are calculated using probability distributions for the input variables and Monte Carlo simulations. Depending on data availability, the estimates can be derived for different levels of analysis (enterprise, household, value chain, wider economy).

In collaboration with the Livestock Information, Sector Analysis and Policy Branch and the Statistics Division, the concept underlying the LIRA has been used to estimate the impact of the 2016/17 drought on Somali livestock keepers within the broader scope of the impact of disasters on agriculture and food security (FAO, 2023). In the following, the approach is illustrated in detail using the risk of *peste des petits ruminants* (PPR) for pastoralists in Somalia.

Example: PPR in Somalia

Somalia's arid and semi-arid climate poses challenges to agriculture, but it is well-suited for livestock production. Most livestock production in Somalia is based on traditional nomadic pastoralism moving livestock in search of water and grazing lands. This mobility allows livestock to access different grazing areas throughout the year. The native breeds of cattle, goats, sheep and camels in Somalia are adapted to survive in the harsh environment and produce milk and meat to serve as food and nutrition and as a source of income. Values of key production parameters for livestock species kept by pastoralists in Somalia, derived from a review of the literature, are presented in Table 1.

Table 1. Key production parameter values of pastoral goats, sheep, cattle and camels in arid and semi-arid areas of eastern Africa

Production Parameter	Goats	Sheep	Cattle	Camels
Age at first parturition (mo)	16.0	17.0	50.0	62.0
Parturition rate (%)	120.0	108.9	60.0	45.0
Prolificacy (nr)	1.2	1.1	1.0	1.0
Milk offtake / lactation (L)	50.0	30.0	290.0	1,200.0
Mortality young (%)	33.0	33.0	22.0	30.0
Mortality sub-adults (%)	12.0	12.0	7.0	7.0
Mortality adults (%)	12.0	12.0	7.0	7.0

PPR, also known as sheep and goat plague, is a highly contagious viral disease that affects wild and domestic small ruminants such as sheep and goats. The disease has the potential to cause significant economic losses due to high mortality rates, especially in young animals, and reduced productivity in survivors.

Table 2. PPR-specific mortality in sheep and goats and disease-related milk yield reduction

[2] Disease risk takes into consideration the probability of occurrence of the disease only while livelihood risk is accounting for disease risk impact.

	n	Median	Mean	SD
Mortality (%)				
Lambs / kids	7	26.2	24.6	16.3
Sub-adults	8	40.8	40.2	18.6
Adults	8	17.3	16.3	9.9
Milk loss (%)				
Adults	2	55.0	55.0	7.1

PPR progresses rapidly and outbreaks can spread quickly within susceptible populations. Reported mortalities of PPR by age group and proportional milk loss of lactating ewes and does are summarized in Table 2. Mortality is highest (~40 percent) in sub-adults, i.e. animals between weaning and reproductive age, and lowest (but still nearly 20 percent), in adults. Disease-specific mortality is treated as additional to the 'background' mortality, and total mortality during the outbreak is calculated as the probability of death from PPR or other causes. For example, the chance of survival during a PPR outbreak for kids and lambs is 0.67 x 0.75, i.e. 0.50 or 50 percent.

Drawing on the above information and using average livestock and milk prices in the region from the Food Security and Nutrition Analysis Unit (FSNAU) price database, the herd model was used to simulate physical offtake and financial returns of goats and sheep over a normal year (baseline) and a year with a PPR outbreak (unmitigated impact). Table 3 displays the results for goats (results for sheep are very similar). Given the nature of the data used, all figures should be taken as indicative rather than definitive.

Table 3. Estimated composition and annual revenue (USD) of a population of 1 000 goats in a normal year (left) and in a year with a PPR outbreak (right)

BASELINE			
INVENTORY	**Unit**	**Start**	**End**
Total F	No.	774.8	827.8
M	No.	225.2	240.6
T	No.	1,000.0	1,068.4
Inventory change	No.		68.4
Inventory value (1,000$)	1,000$		22.3
REVENUE			
Value inventory change	1,000$		1.4
Value of milk offtake	1,000$		12.9
Value of live animal offtake	1,000$		6.4
Treatment costs	1,000$		0.0
TOTAL REVENUE	**1,000$**		**20.7**

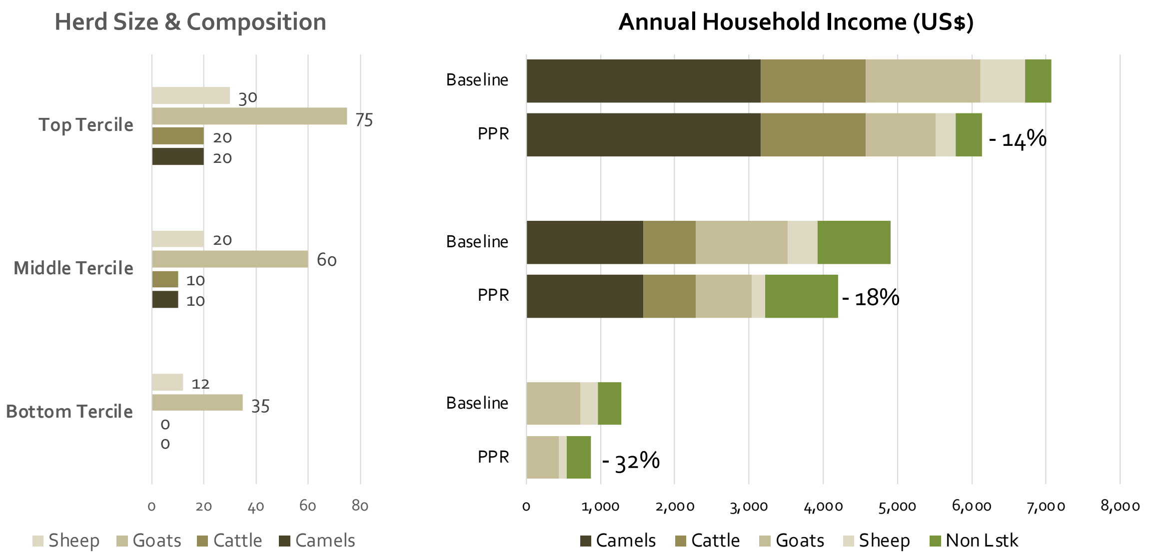
PPR OUTBREAK			
INVENTORY	**Unit**	**Start**	**End**
Total F	No.	774.8	661.7
M	No.	225.2	171.0
T	No.	1,000.0	832.7
Inventory change	No.		-167.3
Inventory value	1,000$	20.8	17.3
REVENUE			
Value inventory change	1,000$		-3.5
Value of milk offtake	1,000$		10.5
Value of live animal offtake	1,000$		5.7
Treatment costs	1,000$		0.0
TOTAL REVENUE	**1,000$**		**12.6**

In a normal year, a goat is estimated to generate a revenue of around USD 21. Sixty-two percent of the revenue from a goat flock is derived from milk and the remainder from animal sales and herd growth. In the case of an outbreak of PPR, annual revenue is estimated to decline by around 40 percent, mostly due to increased mortality which reduces flock size and animal sales, while potential revenue from milk drops by around 20 percent.

The herd model was also used to estimate annual returns accruing from cattle and camels based on production parameters assembled for the region (Table 1) and the FSNAU price database. The estimated annual revenue from cattle amounts to approximately USD 75 per head while camels, due to their far superior lactation yield, generate an average annual revenue of approximately USD 160 per head. Drawing on household data (herd size and composition, income sources, household size, etc.) collected in the Dawa pastoral livelihood zone by FSNAU

(FSNAU 2014), the decline in household revenue resulting from PPR affecting sheep and goats, but not cattle and camels, was estimated for top, middle and bottom tercile households (Figure 2).

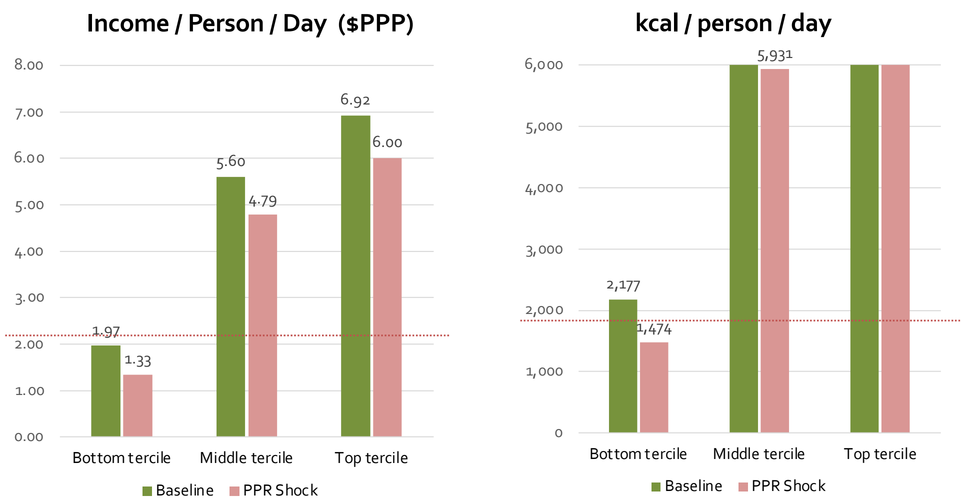
Figure 2. Herd size and composition (left) and estimated PPR impact on household income for top, middle and bottom tercile households (right) in a pastoral area of Somalia



According to FSNAU (2014), top tercile households on average own 30 sheep, 75 goats, 20 cattle and 20 camels, generating an expected annual livestock revenue of close to USD 7 000 in a normal year. Bottom tercile households on average only own 12 sheep and 35 goats and no cattle or camels, providing an estimated annual livestock income of around USD 1 000 in a normal year. Middle tercile households own some cattle and camels and achieve an average annual livestock income of around USD 4 000. As can be seen in Figure 2, in the case of a PPR outbreak, top tercile households suffer the largest absolute but lowest relative loss in livestock income while the opposite is true for bottom tercile households. Having camels and cattle (species not affected by PPR) enhances household resilience against this specific disease threat. Bottom tercile households, only owning sheep and goats, are highly exposed to PPR and can only draw on their non-livestock income to compensate for the 40 percent drop in livestock income.

In order to facilitate comparison with international benchmarks for poverty and food security, household income is converted to USD purchasing power parity (PPP)/person/day and into total calories from the cheapest available source, i.e. locally traded grain. The results are shown in Figure 3.

Figure 3. Estimated livelihoods (left) and food security (right) impact of PPR outbreak on top, middle and bottom tercile households in a pastoral area of Somalia displaying the international extreme poverty line, USD 2.15 PPP/day, and 1 900 kcal/person/day as benchmarks



The simulated impact of a PPR outbreak does not push top or middle tercile households close to the internationally defined lines of extreme poverty (USD 2.15 PPP/person/day) or food insecurity (1 900 kcal/person/day) and PPR thus does not represent a significant livelihoods risk, while bottom tercile households are predicted to be pushed deeper into poverty and to fall from food security levels which are just marginally above to below the critical threshold thereby severely compromising their livelihoods.

Vaccination is a key element in the response to the risk a major PPR epidemic poses to the livelihoods of Somali pastoralists. The input variables and their respective parameters and distribution chosen for the benefit-cost analysis of the vaccination of goats and the results are presented in Table 4.

Table 4. Input and results of a goat enterprise-level analysis of costs and benefits of PPR vaccination

Input Variables	Unit	Distribution	Parameters	Value 1	Value 2
Revenue Difference					
Per animal in affected flock	$	Normal	mean, sd	8.1	1.6
Disease Risk					
Proportion of herds affected	%	Uniform	min, max	25	75
Vaccination					
Cost per animal	$	Uniform	min, max	0.15	0.35
Vaccine efficacy	%	Uniform	min, max	85	95
Results		**Mean**	**SD**	**Min**	**Max**
Avoided losses per animal	$	7.3	1.6	3.8	11.0
Vaccinations per avoided loss	Nr	2.2	0.7	1.4	4.0
Cost per avoided loss per animal	$	0.5	0.2	0.2	1.3
Benefit-Cost Ratio		15.7	7.1	3.6	40.5
Break even investment/animal	$	3.7	1.4	1.1	7.3
Break even loss/animal	$	0.6	0.3	0.2	1.5
Break even risk	%	3.6	1.2	1.7	7.3

Using the herd model, the revenue shortfall per goat in an affected versus a non-affected flock had been estimated to amount to USD 8.1 (Table 3). To account for the uncertainty surrounding the estimate, a normal distribution with a mean of 8.1 and a standard deviation of 1.6 (20 percent) was used to generate input values for the Monte Carlo simulation of the outcome (1 000 iterations). Uniform distributions were used to represent the probability of occurrence of PPR affecting a flock (25 to 75 percent), the cost of vaccinating a goat (USD 0.15 to 0.35) and the efficacy of the vaccine (85 to 95 percent). The results of the analysis indicate that vaccination has an average BCR of 15.7 with a minimum of 3.6, which would still be considered highly attractive. PPR vaccination would break even, i.e. result in a BCR of 1, at a vaccination cost of USD 3.7 per animal, an expected loss of USD 0.60 per animal, or a disease risk of 3.6 percent.

Drawing on the analysis of the livelihoods and food security impact of PPR on three pastoralist wealth groups, a household-level analysis was performed to estimate the cost-effectiveness of two vaccination strategies taking the cost per averted household crisis as metric. The input variables and respective distributions for each of the three groups are shown in Table 5. The average number of small ruminants per household was taken from the FSNAU livelihoods assessment and it was assumed that flock size followed a normal distribution with a relative standard deviation of 10 percent. The same PPR disease risk (25 to 75 percent) was applied across the three groups. The probability of an outbreak of PPR resulting in a livelihoods crisis was assumed to be 100 percent for the bottom tercile while it was set to zero for the other two wealth terciles.

Table 5. Input for the household-level analysis of the cost-effectiveness of PPR vaccination

Tercile	Parameter	Unit	Value	Distribution	Min/Avg	Max/SD
Bottom	SRs/HH	Nr	47	Normal	47	4.7
	P outbreak	%	50	Uniform	25	75
	P livelihood crisis	%	100	Uniform	100	100
Middle	SRs/HH	Nr	80	Normal	80	8.0
	P outbreak	%	50	Uniform	25	75
	P livelihood crisis	%	0	Uniform	0	0
Top	SRs/HH	Nr	105	Normal	105	10.5
	P outbreak	%	50	Uniform	25	75
	P livelihood crisis	%	0	Uniform	0	0

Two vaccination scenarios were assessed to define who is bearing the costs and who is benefiting from a PPR control strategy: (i) blanket vaccination of all small ruminants irrespective of the household wealth group; and (ii) targeted vaccination of small ruminants of bottom tercile households only given PPR does not represent a livelihoods risk for the other two wealth groups. In the first case, the average cost per averted household crisis amounts to USD 149 (standard deviation 68) while for targeted vaccination, assuming the same cost per animal vaccinated, the average cost per averted household crisis only amounts to USD 28 (standard deviation 13) (Table 6).

Table 6. Cost per household livelihoods crisis averted by blanket (left) and targeted (right) PPR vaccination

Tercile	Parameter	Unit	Mean	SD
Bottom	Vaccination cost	$	3,903	1,024
	HH crises averted	Nr	147	44
Middle	Vaccination cost	$	6,689	1,786
	HH crises averted	Nr	0	0
Top	Vaccination cost	$	8,789	2,354
	HH crises averted	Nr	0	0
Total	Vaccination cost	$	19,318	5,002
	HH crises averted	Nr	147	44
	Cost/crises averted	$	149	68

Tercile	Parameter	Unit	Mean	SD
Bottom	Vaccination cost	$	3,903	1,024
	HH crises averted	Nr	147	44
Middle	Vaccination cost	$	0	0
	HH crises averted	Nr	0	0
Top	Vaccination cost	$	0	0
	HH crises averted	Nr	0	0
Total	Vaccination cost	$	3,903	1,024
	HH crises averted	Nr	147	44
	Cost/crises averted	$	28	13

Although from the perspective of safeguarding food security and livelihoods of affected livestock keepers, the targeted vaccination strategy is much more cost effective, it leads to substantially higher disease costs. These are defined as the sum of control expenditure and disease losses. In the blanket vaccination strategy, per 1 000 households, vaccination costs are estimated to be around USD 19 000 while PPR losses would be in the order of USD 31 000 for a total disease cost of approximately USD 50 000. In the case of targeted vaccination, control costs only amount to roughly USD 4 000 but disease losses, incurred mostly by non-vaccinated middle and top tercile households, would amount to approximately USD 256 000 for a total disease cost of USD 260 000 – more than five times the cost of the blanket vaccination scenario. The additional cost of USD 15 000 required to vaccinate small ruminants of middle and top tercile households would reduce their PPR losses by around USD 225 000, i.e. vaccination should be attractive for them even if they have to cover the cost.

Conclusion

The development of LIRA is in the early stages and the PPR example is only intended to illustrate the concept and stimulate discussion. It should not be taken as advocating for any specific PPR control strategy as aspects not covered will have to be considered. Further development of LIRA will build on its application to a wide range of hazards and constraints, such as drought in the Horn of Africa, helminth control in small ruminants in West Africa and lumpy skin disease in the Near East. It is hoped that its application to a diversity of case studies will provide LIRA with the scope and flexibility required for wide uptake.

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