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Livestock CRP pig value chain meeting Uganda – Environment Flagship update

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Environmental sustainability of Uganda pig value chain

Objective

Ensuring environmental sustainability (=reduced environmental footprint and climate-adaptive) of pig value chain upgrades in Uganda

Focus of Environment Flagship in Uganda

1. Heat stress adaptation and climate change
2. Manure management and greenhouse gases
3. Environmental impacts of integrated intervention packages (GHG, water, land…)

Core team

CIAT: Birthe Paul, Jessica Mukiri, Paul Zaake

ILRI: Sonja Leitner, Ibrahim Wanyama

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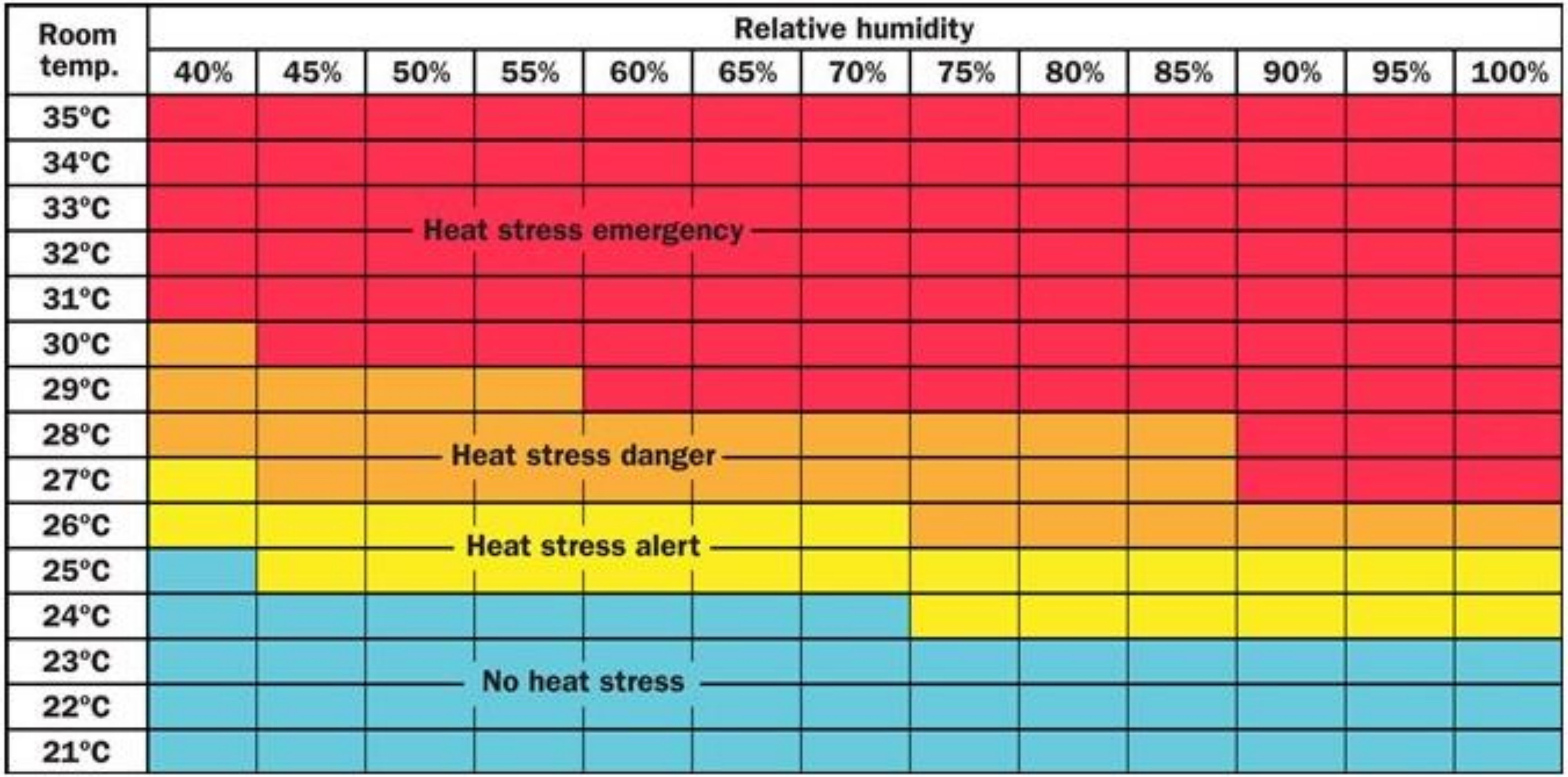
Heat stress and livestock

- When environmental temperature nears an animal's body temperature, the animal's cooling mechanisms are impaired.
- Consequently, the animal's body temperature rises and it shows signs of heat stress.
- It starts to eat less and produces less metabolic heat as a natural protective mechanism.

photo credit: CIP/RTB-ENDURE/Sara Quinn

Temperature Humidity Index (THI)

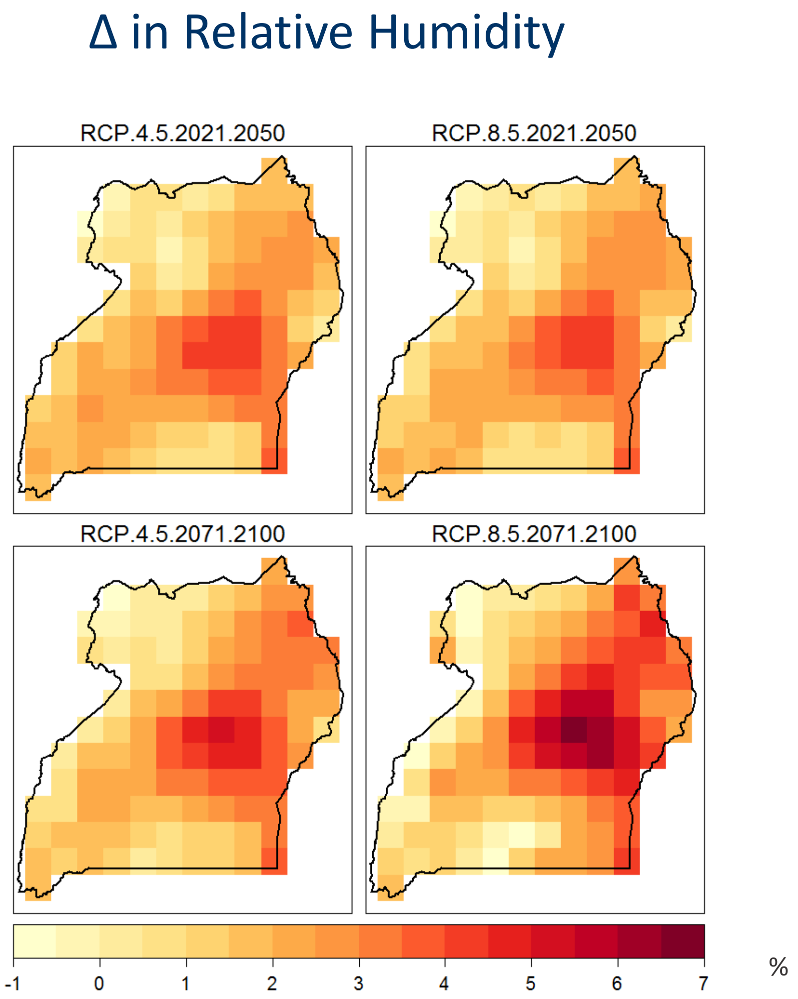


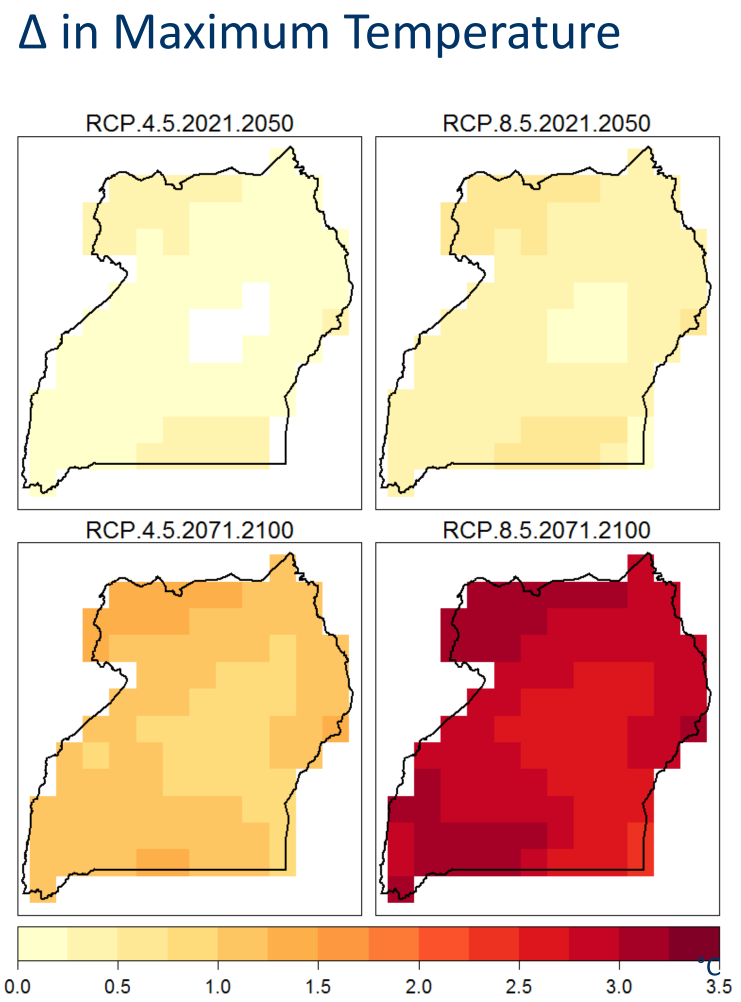
Adapted from Xin, H. and Harmon (1998)

THI thresholds and response in pigs

Category	Swine	Response
None	THI ≤ 74	i. Both productive and reproductive performance are optimum
Mild	74 < THI ≤ 78	i. Livestock body is able to control the heat stress by chemical and physical means. ii. Livestock seek for shade. iii. Increase in their rectal temperature, respiration rate. iv. Dilation of blood vessels
Moderate	78 < THI ≤ 83	i. Body temperature would increase and productive/reproductive performances are expected to be severely affected. ii. Respiration rate would significantly increase. iii. Dry matter intake and ratio of forage to concentrate intake is expected to decrease. iv. Water intake would significantly increase.
Severe and Danger	THI > 83	i. Respiration and excessive saliva production would increase. ii. The productive/reproductive performances will significantly decrease. iii. Rumination and urination will decrease. iv. In extreme cases, the stress would be significantly extreme and livestock may die.

Climate change impacts in Uganda





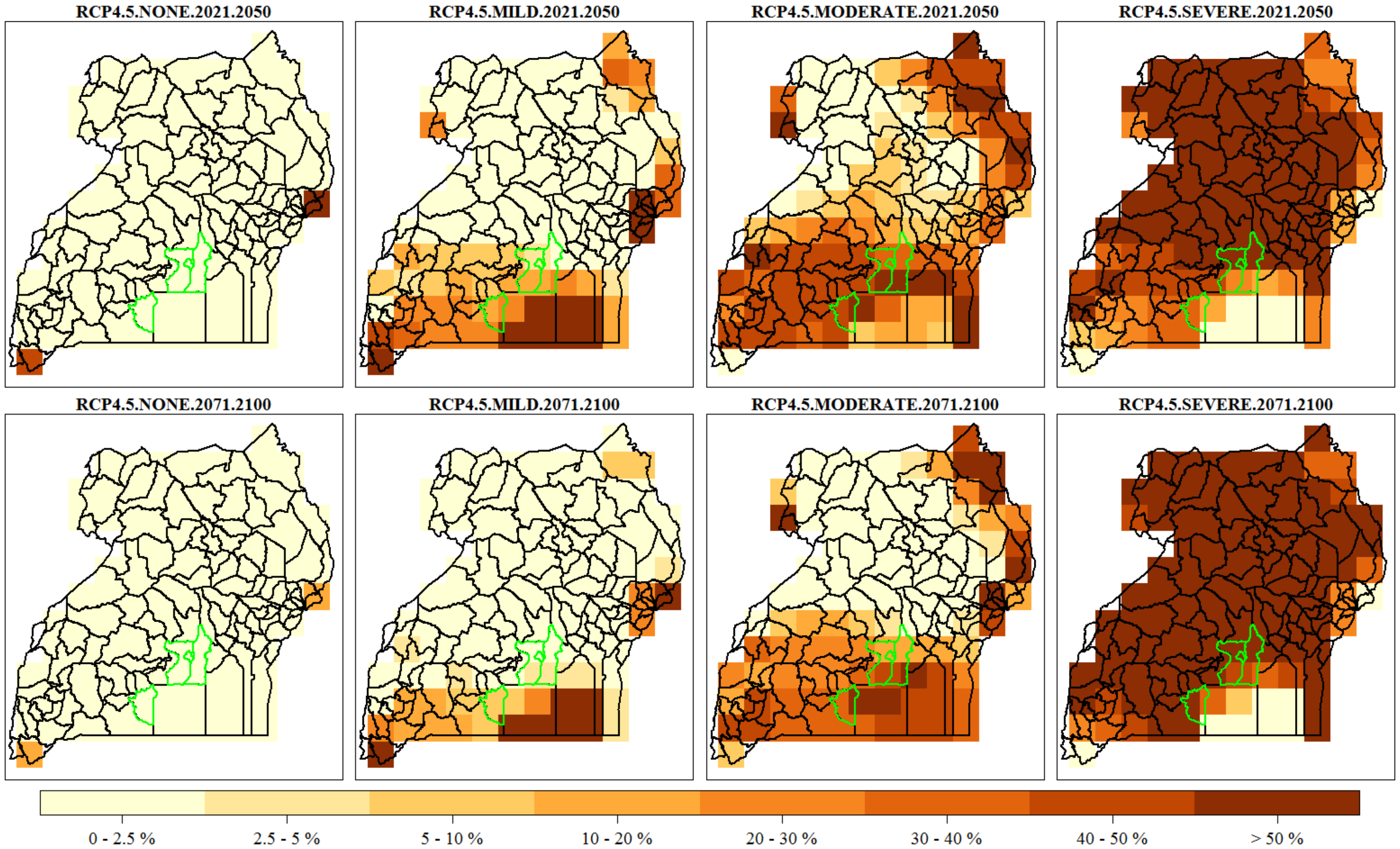
By 2100 maximum temperature is expected to increase by 1.5 and 3.5°C and relative humidity is expected to increase by 4% and 7% based on RCP 4.5 and RCP 8.5 concentration scenarios

Heat stress risk for pigs under moderate climate change

Frequency of different THI categories for swine under RCP 4.5 scenario

By 2021-2050

By 2071-2100



Severe heat stress category is dominant

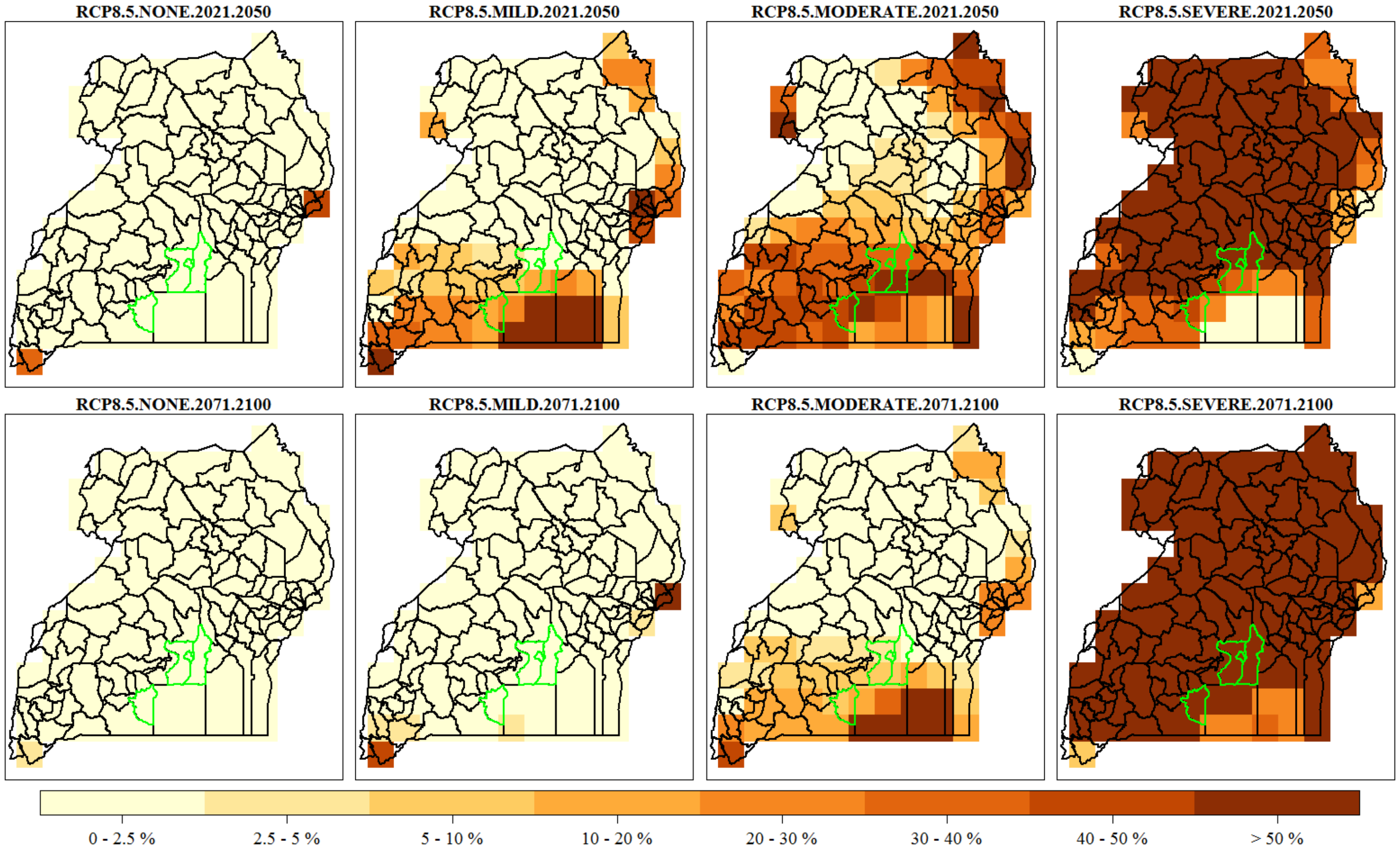
Most of southern parts are experiencing moderate conditions > 20 % of the time

Heat stress risk for pigs under severe climate change

Frequency of different THI categories for swine under RCP 8.5 scenario

By 2021-2050

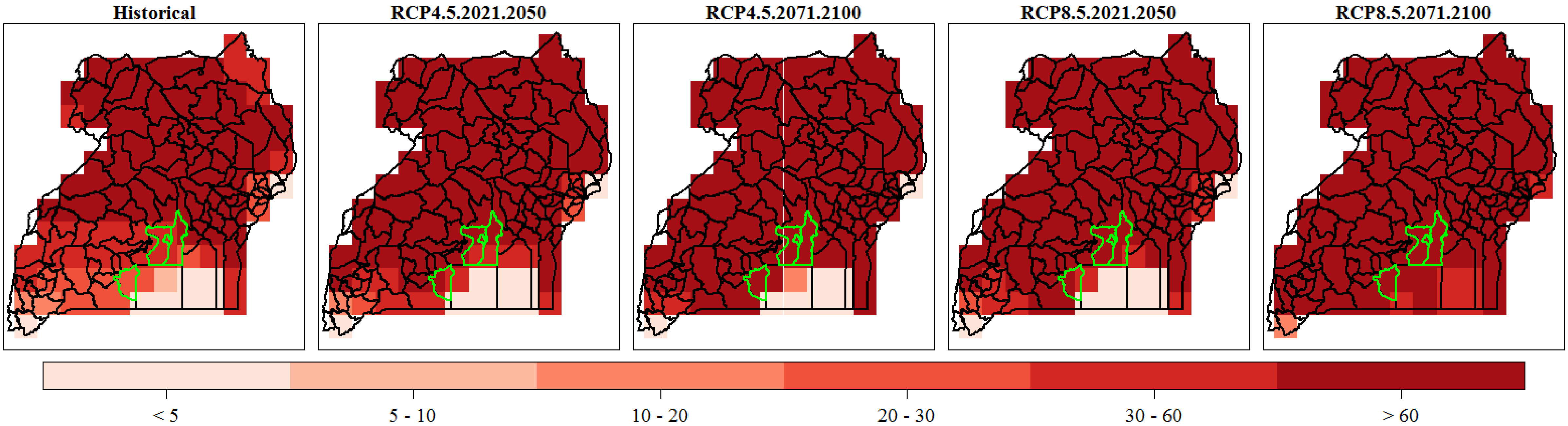
By 2071-2100



Severe heat stress category is dominant

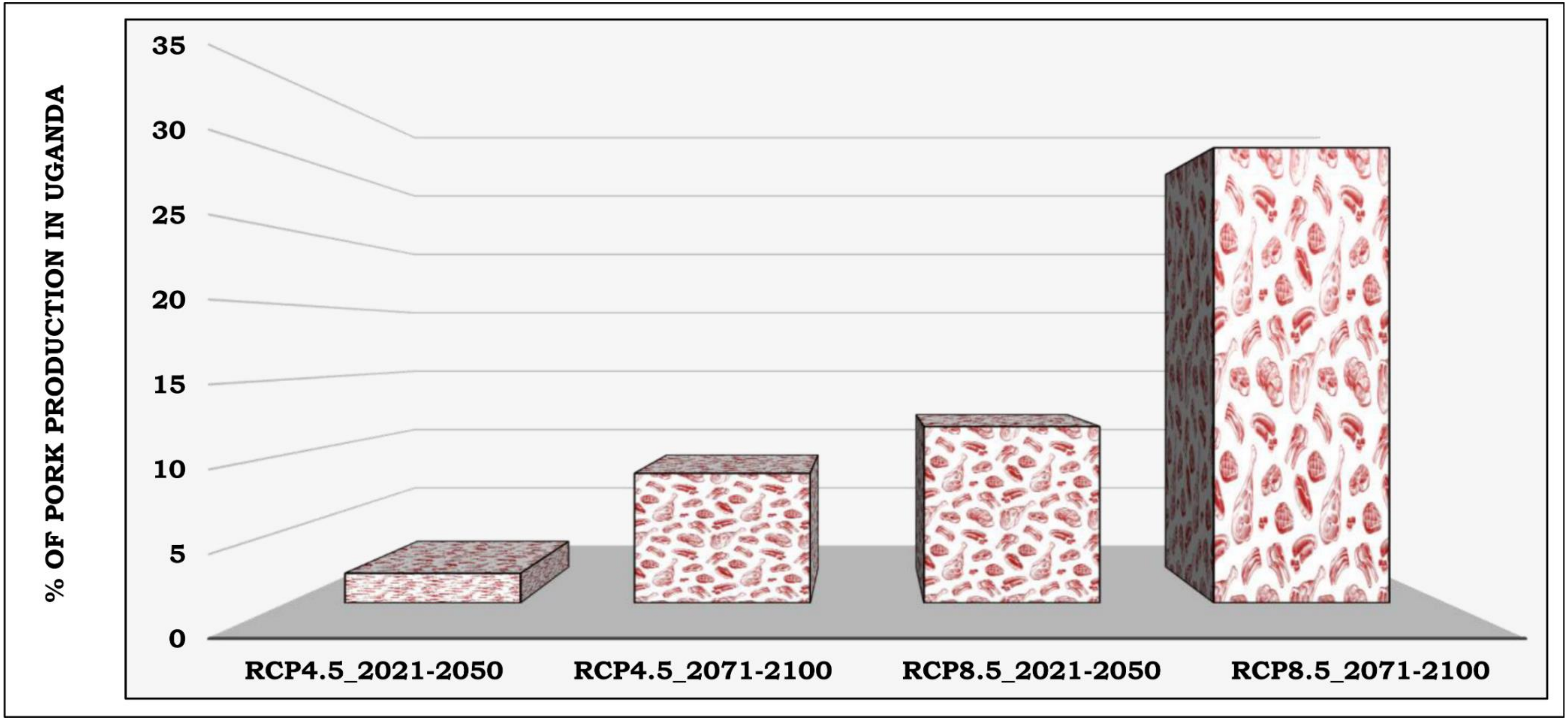
Most of southern parts are experiencing moderate conditions > 30 % of the time

Change in length of consecutive severe/danger heat stress



Average length of continuous severe/danger heat stress is expected to increase by the future period across the whole country

Pork production challenged by increasing frequency of heat stress



Heat stress adaptation content for PigSmart platform

Topic	Target audience							Message Content	Reference
	Farmers	Extension	Aggregator	Butchers	Consumers	Investors	Policy make	Voice (100 words) or text message (160 characters)	
Heat stress								In face of climate change and associated increasing global atmospheric temperature, heat stress affects pigs than before. **Heat-stress** is a condition when the pig body temperature exceeds a threshold to an extent that the pig is unable to maintain homeothermy because of high heat from environment, and metabolic activities. Pigs are sensitive to heat stress because they do not have functioning sweat glands and therefore prefer low ambient temperatures depending on stage of growth and reproduction.	Soren et al., 2018; IPCC, 2018; Martínez-miró et al., 2016; St-Pierre et al., 2003; Nardone et al., 2010
Heat stress								Our climate is changing and air temperature is becoming higher during most months of the year than it was about 30 years before. When 'heat from sun' is high and it adds to high 'heat from body of the pig', the animal may **'experience high temperature'**- a situation we call 'heat stress' in science. Naturally, a pig does not sweat, so 'heat stress' affects it.	Soren et al., 2018; IPCC, 2018; Martínez-miró et al., 2016; St-Pierre et al., 2003; Nardone et al., 2010
Heat stress								Heat stress leads to low pig immune system increasing risk to diseases like Africa Swine Fever. During heat stress, the average daily feed intake is low (about 1kg lower feed than normal), leading to reduced weight gain and general growth. The pork from heat stressed pig is of poor quality including being fatter, smeary, and have low shelf life. Pig reared for breeding purposes is affected by 'heat stress' because it leads to low libido, fertility, embryo survival, fetal growth and pregnancy rate. All these lead to low profits or high losses.	White et al., 2018; Abdurehman and Ameha, 2018; Patience et al., 2015; Pearce et al., 2013; Atuhaire et al., 2013; Renaudeau et al., 2011; Kumar et al., 2011; Nardone et al., 2010; St-Pierre et al., 2003
Heat stress								Pig experiencing high-temperature (heat stress) eats little feed each day and adds less weight, therefore growing slowly. The pork from pig that experienced high temperature has 'many fats' and is smeary. Pork cannot be stored for a longer period. During high-temperature, the pig may not even mate because heat-stress makes male pig have low libido, and female pig have low fertility. Even when mating occurs, the female pig may not become pregnant. For heat stressed pregnant pig, the fetus (young pig growing inside the pig) may grow slowly or not survive. These lead to low income or losses.	White et al., 2018; Abdurehman and Ameha, 2018; Patience et al., 2015; Pearce et al., 2013; Atuhaire et al., 2013; Renaudeau et al., 2011; Kumar et al., 2011; Nardone et al., 2010; St-Pierre et al., 2003
Heat stress								In Uganda, majority of pigs experience heat stress. A pig experiencing heat stress will have high respiration rate, pulse rate, rectal temperature, and skin temperature. The blood of heat-stressed pig has high heat shock proteins. The pig under heat stress seeks for shade, has high demand for drinking water, but low appetite for feed.	Zaake et al., 2019) (White et al., 2018) (Mutua, 2017; (Fernandez, 2014; Sipos et al., 2013) (Huynh et al., 2005; (Huynh et al., 2006) Nardone et al., 2010)
Heat stress								Researchers found that most pigs in Uganda experience high temperature (heat stress). A pig experiencing heat stress will have higher body-temperature, breathe faster, the heart will 'pump' or 'beat' faster than normal. The pig will tend to seek for shade and drink high amount of water.	Zaake et al., 2019) (White et al., 2018) (Mutua, 2017; (Fernandez, 2014; Sipos et al., 2013) (Huynh et al., 2005; (Huynh et al., 2006) Nardone et al., 2010)

Publications on heat stress and adaptation

Zaake, Paul; Paul, Birthe; Marshall, Karen; Notenbaert, An; Ouma, A. Emily; Dione, Michel M.; Ouma, George O.; Ndambi, Asaah O., 2020, "Pig production in Uganda - adapting to climate change", https://doi.org/10.7910/DVN/KPVH8Q, Harvard Dataverse, V1

Zaake, P., Ndamibi, A.O., Paul, B.K., Marshall, K., Notenbaert, A., Ouma, E., Dione, M.M., Ouma, G. Pig production in Uganda - adapting to climate change. Oral presentation at Tropentag. http://www.tropentag.de/links/Zaake_UXzm2iKo.pdf

Zaake, P., Paul, B.K., Marshall, K., Notenbaert, A., Ouma, E., Dione, M.M., Ouma, G., Ndamibi, A.O. Heat stress in pigs and adaptation options in Uganda: influencing factors and farmers' perceptions. Prepared for submission to *Climate and Development*

Mutua, J.Y., Paul, B.K., Marshall, K., Notenbaert, A. Mapping current and future heat stress in pigs. Pending minor revisions in *Animal.*

Progress in 2019 – manure management

Literature review finalized and about to be published on CGSpace

- Only little Uganda-specific information found
- Pig manure related to health and environmental concerns: source of 5% of livestock sector emissions, host of parasites and pathogens, acidification of rain water, eutrophication
- Little knowledge on manure management across different production systems
- Little attention given to pig manure as it is perceived as waste

Wanyama, I. and Leitner, S. 2019. *A review on health and environmental aspects of current manure management practices in pig production systems in Uganda.* ILRI.

Pig manure composition

Components	Fresh Pig manure (Okoli et al. 2019); Nigeria	Pig vs Cattle fresh manure (Alvåsen 2009); Uganda		Pig vs Cattle fresh manure (Nyamangara et al. 2010); Zimbabwe	
	Pig- fresh	Pig -fresh	Cattle- fresh	Pig- fresh	Cattle -fresh
Nirogen (%)	2.25±0.08	3.5	1	3.1	0.8
C:N ratio	7.8	11.8	31.8	4.3	14.3
Phosphorus(ppm)	2.4±0.28	-	-	-	-
Potassium (%)	8.27±1.29	-	-	-	-
Calcium (%)	0.03±0.01	-	-	-	-
Sodium (%)	0.07±0.03	-	-	-	-
Magnesium (%)	0.01±0.00	-	-	-	-
Sulphur (%)	0.47±0.12	-	-	-	-
Carbon (%)	18.1±0.49	-	-	-	-
Iron (mg/100g)	1885±880	-	-	-	-
Zinc (mg/100g)	8.97±3.01	-	-	-	-
Manganese (mg/100g)	6.79±3.32	-	-	-	-
Cobalt (mg/100g)	6.79+3.32	-	-	-	-
Copper (mg/100g)	2.73±2.66	-	-	-	-
Aluminium)mg/100g)	19.6±7	-	-	-	-
Lead (m/100g)	0.96±0.6	-	-	-	-
Cadmium (mg/100g)	0.97±0.6	-	-	-	-
Chromium (mg/100g)	6.0±2.4	-	-	-	-
Silver (mg/100g)	1.3±0.6	-	-	-	-

- Composition depends of dietary intake
- Generally pig manure richer in N
- C:N is lower

Sustainable Manure management

Composting

- Bio-oxidation of organic matter
- Temperatures can rise to up to 80 °C - eliminates most pathogens
- Antibiotics are degraded
- Stable compounds-less susceptible to denitrification, leaching and volatilization
- Reduce GHG by 91%
- Reduce eutrophication by 65%

Vermicomposting

- Use of worms to feed on manure/waste
- Products: Worm biomass (livestock feed) and organic fertilizer
- Reduce manure biomass and nutrients by over 50%
- Reduce GHG by 70%
- Reduce Eutrophication by 88%

Biogas production

- Produced anaerobically
- Pathogens are killed in the process and digeste is a good fertilizer
- Challenges - costs involved, technical, availability of manure over time

Pig production systems

Free range

- Pigs left to scavenge
- Practiced mainly in rural areas
- Dry season when forages are limited
- No/limited manure management

Tethering/semi-intensive

- Restricted in garden – forage, fed on home refuse
- Occasionally moved from point to point
- Some level of management-spreading and incorporating in soil

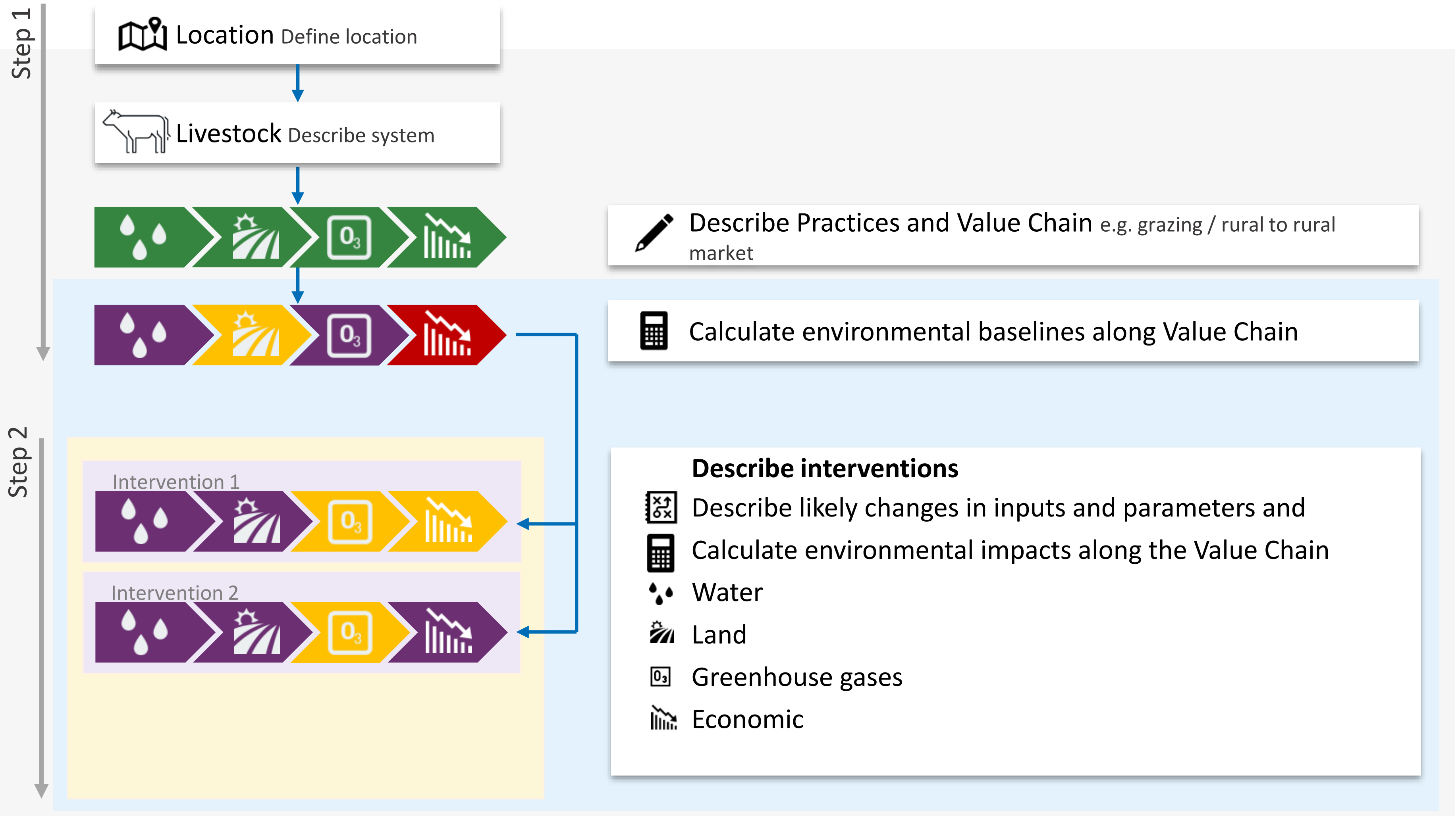
Intensive

- Commercial nutrient-rich feeds
- Housed
- Peri-urban and urban areas
- Manure washed in pits or piled in heaps
- 48% applied in fields, 40% disposed in dumping areas

Manure management content for PigSmart platform

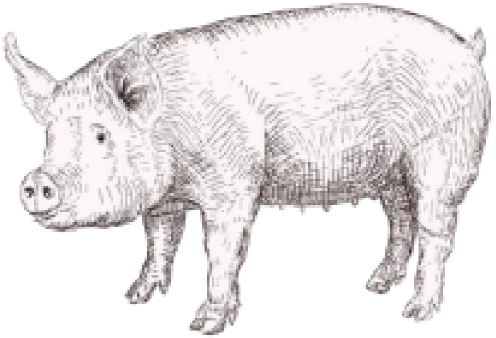
Topic	Target audience							Message Content	Reference
	Farmers	Extension	Aggregator	Butchers	Consumers	Investors	Policy makers	Voice (100 words) or text message (160 characters)	
Manure Management	■	■			■		■	Untreated manure may contain pathogens that cause disease in humans and livestock, and may also include antimicrobial- resistant pathogens which render disease treatment more expensive, more toxic and longer to heal. If not managed well, manure also pose environmental contamination through acidifying rain water, greenhouse gas emissions, and development of alga and water hyacinth in water bodies.	Dione et al. 2018; Gurtler et al. 2018; Hooda et al. 2000; Petersen et al. 2013
Manure Management	■	■						Routine collection of manure from tethering areas and pig houses has been shown to significantly reduce incidence of gastrointestinal infection among the pigs.	Roesel et al. 2017
Manure Management	■	■					■	Manure treatment through compositing and vermicomposting. Compositing process eliminates pathogens such as Salmonella, Coliforms and feacal streptococci. Compositing also stabilizes plant nutrients and reduces GHG emissions. Vermicomposting of manure is used for worm biomass production, which is a high protein source for poultry and pigs, and produces high-quality organic fertilizer. Recommendable for urban intensive system	Gurtler et al. 2018; Tiquia et al. 1998; Mc arthy et al. 2011; Paul et al. 2001; Lalander et al. 2015
Manure Management	■	■				■	■	Biogas production from manure to obtain clean energy can help to reduce GHG emissions as the produced methane is burnt as biogas. Additionally, manure pathogens are killed in the process of fermentation, odors are reduced, and the remaining manure bioslurry is a high-value nutrient-rich fertilizer for crop production.	Owusu & Banadda 2017
Manure Management	■	■					■	Safety precautions while handling manure should be observed rather than using hands. Farmers should use hoes or spades to scoop manure as well as gumboots and where possible gloves should be used to avoid direct contact with the manure.	FAO,2012; Lupindu et al. 2012
Manure Management	■	■						Transformation of production system from free range to some level of confinement such as tethering can help to reduce disease infections and make manure collection, treatment and use easier.	
Manure Management		■					■	Pig Manure is regarded as a waste that pollutes the environment and potential health hazard and not a resource. Policy makers and other actors need to be sensitized on the benefits and how management can address environmental and health hazards. Some countries in Africa have manure management policies but enforcement is weak. Manure management is also not mentioned in the Uganda fertilizer policy	Lupindu et al. 2012; Ndambi et al. 2019; Uganda National fertilizer policy (http://extwprlegs1.fao.org/docs/pdf/uga172925.pdf)

CLEANED environmental impact process



Update of CLEANED model with pig-specific calculations

- Land requirements
- Productivity
- Economics
- Soil Impacts
- Water impacts
- GHG emissions



For pigs the following additional parameters are required:

- Litter size
- Lactation length
- Proportion of piglet growth covered by milk
- LW gain piglets
- Lysine requirements

Additional protein (lysine) requirement calculations for pigs:
The protein requirement of pigs is expressed as lysine, and we assume that pig protein contains 12% of lysine[2] .To calculate protein requirements, we assume that the protein in feed suitable for pigs contains 4% lysine.

Mukiri J; Notenbaert A; van der Hoek R. 2019. Report on refinements of CLEANED X Versions 2.0.1. International Center for Tropical Agriculture. 9p. https://hdl.handle.net/10568/107020

Example output of CLEANED

To what extent do the integrated packages of farm level interventions (feed + health + genetics + environment) translate into higher productivity and reduced environmental trade-offs?

		Productivity		Land requirements		Erosion			Nutrients			GHG emissions		
		Total supply (FPCM)	Productivity (FPCM/ha)	Land used (ha)	Land used per product (ha/MT FPCM)	Soil lost (kg)	Soil lost per area (kg/ha)	Soil lost per product (kg/MT FPCM)	N lost (kg)	N lost per area (kg/ha)	N lost per product (kg/kg FPCM)	Total emissions (kg CO2-eq)	Emissions per area (kg CO2-eq/ha)	Emissions per product (kg CO2-eq/MT FPCM)
Mixed crop-livestock enterprise	Genetics		-	-	-	-		-	-		-	-		-
	Feed	+++	+	---	+	---	+	++	---	+	++	---	-	
	Health	+++	+	---	+	---		+	---	+	+	---		+
	Combined	+++	++	---	++	---	+	++	---	+	++	---	-	+
Agro-pastoral enterprise	Genetics	++	+++	++	++	++		++	++		+++	+	-	++
	Feed	++	+++	++	+++	++	+	+++	++		+++	--	---	+
	Health	++	+++	++	+++	++	+	+++	++		+++	--	---	+
	Combined	+++	+++	-	++	-	+	+++	-	-	+++	--	-	++
Tanga VC	Genetics	+	++	+	+		-	+		-	+		-	+
	Feed	++	+++	+	++	+		++	+	-	++	--	---	+
	Health	++	++	+	++	+		++		-	++	--	--	
	Combined	+++	+++	-	++	-	+	++	-	+	++	--	-	+

Notenbaert, A., Mukiri, J., Van der Hoek, R., Paul, B., Koge, J., Birnholz, C. (2019). CLEANED X - Version 2.0.1.
https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/G0G8IY

Progress in 2019 – environmental impacts (CLEANED)

- Kigosi Abasi from NaLIRRI will come to Nairobi for intensive CLEANED training and model application end of March, following up on an initial training end of 2018. This adds a capacity building element. We are checking whether we can include a second participant from MAAIF
- We are currently trying to put together the pig production systems across the 4 sites, and the integrated intervention packages that we can run as scenarios
- Sites: Mukono, Wasiko, Masaka (or where producers are based)

Health	Genetics	Feeds and Forages
3	4	3
Application of herd health services at farm level	Pilot testing of a community-based AI model	Improving the quality of commercial feeds through a training and certification model.
Strengthen advisory services in best practices in diseases control and husbandry using PigSmart	Capacity building of farmers on AI	The selection of and testing of superior and heat tolerant forages (Urochloa and Megathyrsus grasses) and food/feed crop cultivars for pig feeding
Disease reporting platform	Capacity building of AI service providers	Making balanced, least-cost rations (using Feed Calculator) based on forages and other local feed resources for pig feeding.
	Strengthening linkages between AI service providers and semen suppliers	

2020 planning and questions

1) Heat stress and climate change

- Adaptation workshop
- Policy brief and awareness
- Farmer training, which format?
- PigSmart roll-out, which format?

2) Manure management

- PigSmart roll-out, which format?
- Manure management survey for site-specific and production system-specific recommendations

3) CLEANED

- Intensive training in Nairobi in March
- First results on GHG, water, soil impacts later throughout the year that we can present for feedback
- Task now is to define smallholder systems (by sites?) and intervention packages
- For parameterization we will need secondary data – RHoMIS, but any other if available (FEAST?)

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Thank you!

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