



Animal Space Requirement Calculator: A tool to estimate the space requirement of livestock and poultry

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Abstract

Animal space allowance greatly influences the welfare and performance of livestock and poultry, affecting its profitability. At present, no space requirement calculator for animals accommodates a diverse range. Existing online calculators are restricted to individual animal types. The current research developed the Animal Space Requirement Calculator (ASRC), a user-friendly ICT-based tool that calculates an animal space requirement based on its number, size, age, class, floor type, and growth stage. It is a calculator created in a C-programming language that comprises a combination of user-defined inputs and formulas based on the Philippine National Standards. The calculator underwent a series of trials until it reached an accuracy of 100%. The ASRC calculations were used to generate graphs showing the linear relationship between the floor space area and the number of animals. The developed ASRC and the graphs will be a helpful guide for livestock and poultry producers.

Keywords: Floor space, stocking density, housing, estimate, structural requirement

Introduction

The animal space requirement, or the minimum floor space requirement, plays a critical role in the welfare and performance of livestock and poultry. Animal production is largely intensified to meet the world's increasing food demand; however, overstocking should be avoided as it is reported to have negative effects on the performance and economic aspects of farming. Overstocking has been reported to influence animal behavior, causing fear and stress (Zabir et al., 2021) arousing controversy among concerned groups. Overstocking also results in decreased live body weights of swine (Kim et al.,

2017) and broilers (Zabir et al., 2021), as well as decreased milk production in goats (El Sabry & Almasri, 2023) and dairy cattle (Grant, 2007). Meat quality (El Sabry & Almasri, 2023) and cleanliness (Zabir et al., 2021) of animals are also linked to the space allowance. Hence, the serious consideration of the space requirement.

Nowadays, Information and Communication Technologies (ICTs) are being used by extension workers and farmers as decision support systems for farming. Therefore, information about the optimal space requirement of livestock and poultry should be

readily accessible. Currently, there is no available calculator in the Philippines for computing the space requirement of farm animals. While online calculators developed by other countries are available, they are limited to specific types of animals (ManitobaPork, n.d.; Meat and Livestock Australia, 2013; Poultry Health, 2023). To address the issue, the current research has developed the Animal Space Requirement Calculator (ASRC), an ICT-based tool that calculates an animal's space requirement based on its number, size, age, class, and growth stage.

The ASRC is based on the Philippine Agricultural Engineering Standard (PAES), a

technical reference used by Agricultural and Biosystems Engineers, providing general standards for agricultural structures to ensure quality and safety for livestock and poultry. The ASRC includes a variety of farm animals raised in the Philippines. In addition to space requirements, the ASRC also provides recommendations for other structural aspects such as the roof, floor, walls, and suitable location. With the ASRC, engineers, extension workers, and farmers can easily estimate animal space requirements at any time and from anywhere.

Materials and Methods

The ASRC is a tool to estimate the minimum floor space requirement of livestock and poultry. It is a calculator created in a C-programming language. The workflow of the calculator comprises a combination of user-defined inputs and formulas (Figure 1). It contains two sections: (1) animal space requirement calculation and (2) structural requirement recommendation. The ASRC can estimate the animal space requirement for swine, goats, and sheep on a solid floor, goats and sheep on a slotted floor, goats and sheep on an open yard, goats and sheep on lactating, cattle feedlot, cattle ranch, dairy cattle, carabao feedlot, broiler, and layer.

The ASRC uses required inputs and formulas (Table 1), where the user must select the animal desired on the menu, select the target growth stage on the sub-menu, and input the number of animals. Finally, the ASRC calculates the animal space requirement using the formula corresponding to the animal. The formula is the space required per animal (m^2/animal) multiplied by the number of animals desired (N_a). The stage (Sub-menu) pertains to the floor type, class, age, size, and weight of the animals. It includes floor type because animal space requirement varies for different floor types. Various floor types are solid, slotted, litter, and slot-litter.

The second section of the ASRC, the structural requirement recommendation, includes specifications on the roofing material, ceiling height, building sidewall, and concrete floors. It is based on the Philippine National Standards for Housing of Swine (PAES 401, 2001); broiler (PAES 402, 2001); layer (PAES 403, 2001); cattle ranch (PAES 406, 2001);

Housing for dairy cattle (PAES 407, 2001); goat and sheep (PAES 404, 2001); and Carabao Feedlot (PAES 408, 2001).

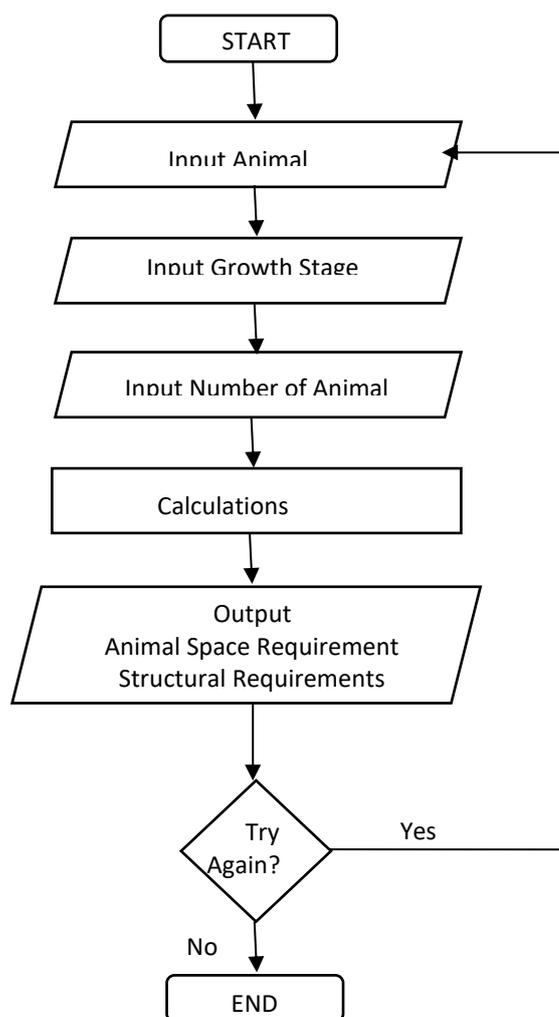


Figure 1. The ASC sequence of execution

Table 1. Formulas and required Inputs of the ASRC to estimate the animal space requirement of different livestock and poultry.

Menu Item Key	ANIMAL	Sub-menu Item Key	STAGE	SPACE REQUIREMENT (m ²)
"S"	Swine	"1"	Up to 10 kg	0.11Na
		"2"	11 - 20 kg	0.20Na
		"3"	21 - 40 kg	0.35Na
		"4"	41 - 60 kg	0.50Na
		"5"	61 - 80 kg	0.70Na
		"6"	81 - 100 kg	0.85Na
		"7"	Gilts up to mating	1.00Na
		"8"	Adult pigs in groups	2.50Na
		"9"	Gestating sows	1.20Na
		"10"	Boar pens	7.50Na
		"11"	Lactating sows and litters: Individual pens	7.40Na
		"12"	Lactating sows and litters: Multi-suckling groups	5.60Na
		"13"	Dry sows	1.80Na
"G"	Goat and Sheep (Solid Floor)	"1"	Doe/Ewe 35kg	0.80Na
		"2"	Doe/Ewe 50kg	1.10Na
		"3"	Doe/Ewe 70kg	1.40Na
		"4"	Kid/Lamb	0.40Na to 0.50Na
		"5"	Buck/Ram	3.00Na
"T"	Goat and Sheep (Slotted Floor)	"1"	Doe/Ewe 35kg	0.70Na
		"2"	Doe/Ewe 50kg	0.90Na
		"3"	Doe/Ewe 70kg	1.10Na
		"4"	Kid/Lamb	0.30Na to 0.40Na
		"5"	Buck/Ram	2.50Na
"Y"	Goat and Sheep (Open Yard)	"1"	Doe/Ewe 35kg	2.00Na
		"2"	Doe/Ewe 50kg	2.50Na
		"3"	Doe/Ewe 70kg	3.00Na
"L"	Goat and Sheep (Lactating)	"1"	Pregnant 50-70kg	1.30Na
		"2"	Pregnant over 70kg	1.60Na
		"3"	Lactating 50-70kg	2.00Na
		"4"	Lactating over 70kg	2.30Na
"F"	Cattle Feed Lot	"1"	Shed Area	4.00Na
		"2"	Loafing Area	5.00Na
"R"	Cattle Ranch (Holding Pen)	"1"	Up to 270 kg	1.30Na
		"2"	270kg-540kg	1.60Na
		"3"	Over 540kg	1.90Na
"D"	Housing for Dairy Cattle	"1"	Calves (up to 3 months)	1.00Na
		"2"	Calves (3 - 6 months)	2.00Na
		"3"	Calves (7 months - one year)	3.00Na
		"4"	Yearlings (1 - 2 years)	4.00Na
		"5"	Heifer/Steer (2 - 3 years)	5.00Na
		"6"	Milking and dry cows	6.00Na
		"7"	Cows in maternity stall	10.00Na
"K"	Carabao Feedlot	"1"	Any size	4.00Na
"E"	Layer	"1"	Growing (7-22 weeks) Litter Floor	0.14Na
			Slotted Floor	0.06Na
			Slot-litter Floor	0.07Na
		"2"	Laying(beyond 22 weeks) Litter Floor	0.17Na
			Slotted Floor	0.09Na
			Slot-litter Floor	0.14Na
"B"	Broiler	"1"	4 weeks and below	0.0625Na
		"2"	Above 4 weeks old	0.1250Na

Note: The table shows the formulas adapted from Belonio (2006). For the kid/lamb, which has a range of space requirements, the ASRC uses the highest value. The ASRC is limited to the animals shown on the table.

The researchers validated the calculator by running every menu and submenu item and calculating the accuracy using the formula below:

$$\text{Accuracy (\%)} = \frac{\text{Calculated Quantity}}{\text{True Value}} \times 100$$

The calculator was adjusted until it reached an accuracy of 100%.

Result and Discussion

Performance of the Calculator

The ASRC is an Interactive tool where the user can customize the type, stage, and number of animals to view their different specifications; this helps the user make decisions and choices. Figure 2 shows that the developed calculator can accurately calculate the amount of floor space required per selected animal of a user and the construction requirement for the particular farm structure.

The author uses the data generated by the ASRC to create the different graphs shown below Swine up to mating (Figure 3a); Adult swine (Figure 3b); Goat and sheep on a solid floor (Figure 4a); Goat and sheep on the slotted

floor (Figure 4b); Cattle Feedlot (Figure 5); Dairy Cattle (Figure 6); Broiler (Figure 7); and Layer (Figure 8). The positive linear relationship between the floor space and the number of animals indicates that the floor space required increases with the number of animals that will occupy the space. Livestock and Poultry producers in the Philippines can use these graphs to estimate the space requirements of different animals. Agricultural Engineers and extensionists can also use the graphs to quickly come up with estimates, decisions, and recommendations while in the field.

```
WELCOME
-----
ANIMAL SPACE CALCULATOR
-----

Select the animal you are interested in:
[1] Swine
[2] Goat and Sheep(Solid Floor)
[3] Goat & Sheep(Slotted Floor)
[4] Goat and Sheep(Open Yard)
[5] Goat and Sheep(Lactating)
[6] Cattle Feed Lot
[7] Cattle Ranch(Holding Pen)
[8] Housing for Dairy Cattle
[9] Carabao Feedlot
[10] Layer
[11] Broiler

Type the number of animal you are interested in here: 1
Your selected animal is Swine

Select your target growth stage:
[1] up to 10kg
[2] 11 to 20kg
[3] 21 to 40kg
[4] 41 to 60kg
[5] 61 to 80kg
[6] 81 to 100kg
[7] Gilts up to mating
[8] Adult pigs in groups
[9] Gestating sows
[10] Boar pens
[11] Lactating sows and litters Individual pens
[12] Multi suckling groups
[13] Dry Sows

Type the number of growth stage in here: 2
You chose Swine 11 to 20 kg.

Enter the target number of Swine 11 to 20 kg: 12
The Minimum Space Required is 2.40 Square meters.

Structural Requirements:

Roof: Roofing material should be made of corrugated G.I. sheets and other durable roofing materials. At least one-meter roof overhang shall be provided to ensure shade and to protect the swine from rain.

Ceiling (optional): Ceiling height shall be at least 2.4 m high.

Walls: Building sidewalls shall have a minimum height of 1 m and shall be made of durable materials.

Floors:
Solid floors: Concrete floors shall be paved on a well compacted gravel fills. Floor shall be skid-resistant with 2 percent to 4 percent slope towards a gutter or drainage canal. The direction of the slope shall be away from the feeding trough.

Slotted floors: Slotted floors should be made of concrete, plastic, metals or combination of such materials. It shall be constructed to allow manure and urine to pass through.

NOTE: Wood is not recommended as flooring material because it is less durable, difficult to dry hence may harbor pathogenic organisms, and wood splinters may cause injury to swine.

Source: PAES 401:2021

Would you like to try again(y/n?): n

Thank you!

Process returned 0 (0x0) execution time : 34.999 s
Press any key to continue.
```

Figure 2. Screenshot of the ASC displaying the output calculations for twelve (12) numbers of swine under the 11 kg to 20 kg category and its structural requirement.

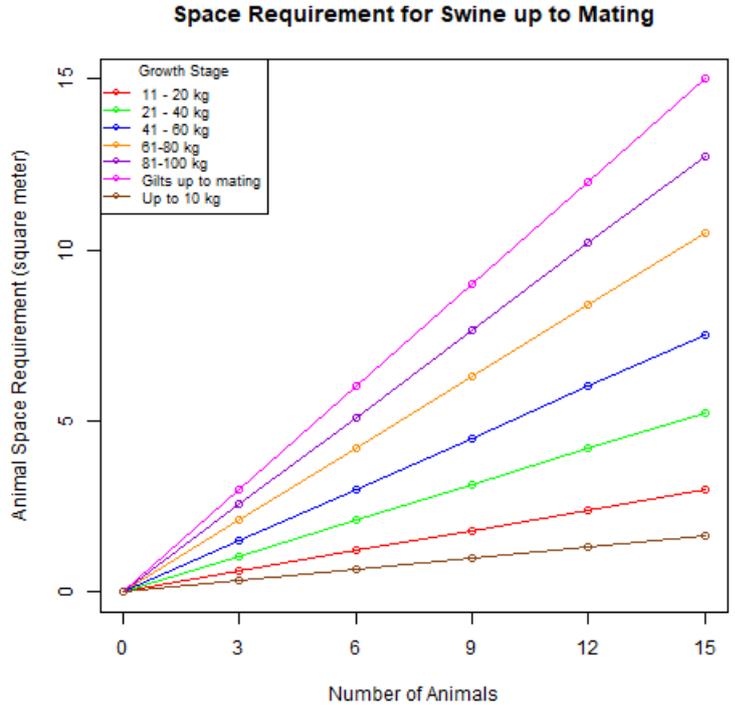


Figure 3a. Graph showing the Space Requirements for Swine under different growth stages up to Mating.

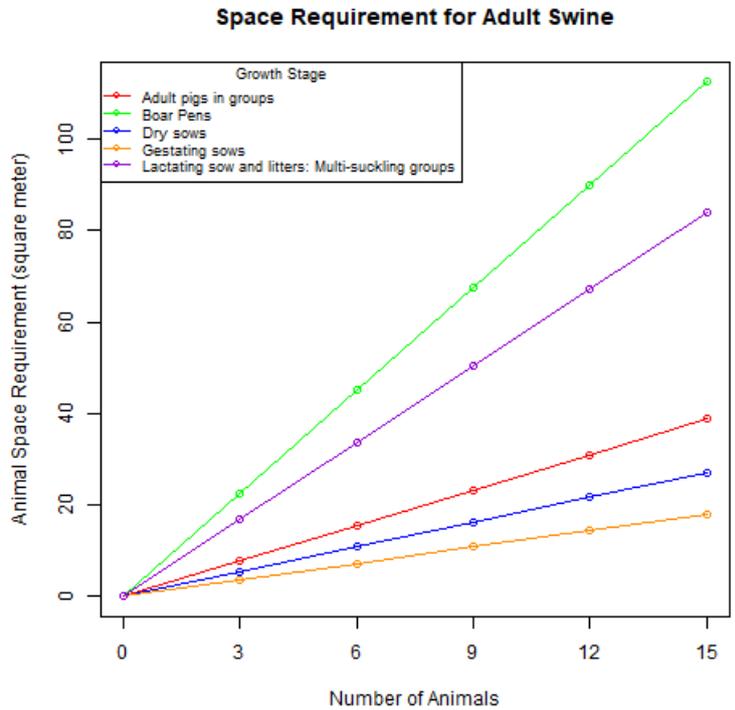


Figure 3b. Graph showing the Space Requirements for Adult Swine

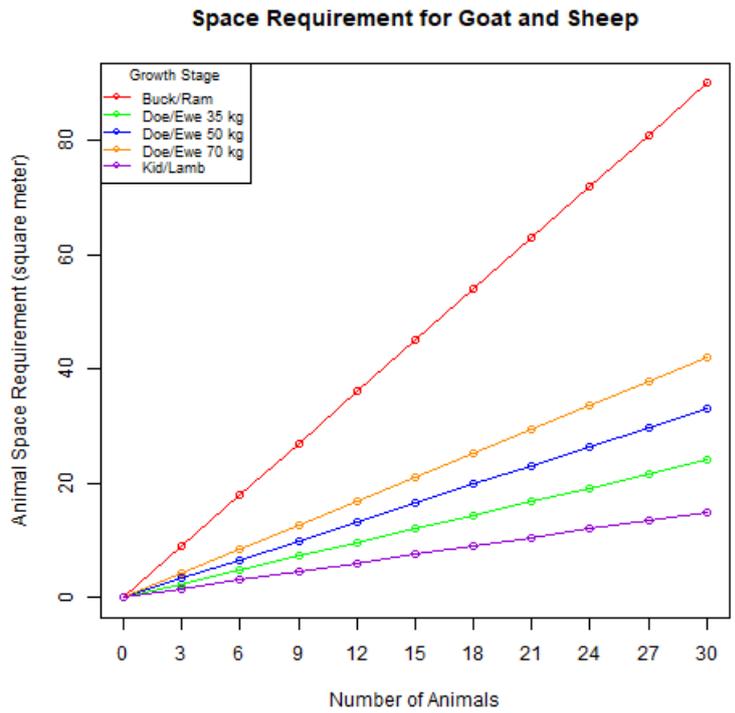


Figure 4a. Space Requirement for Goat and Sheep of different growth stages on housing with Solid Floor

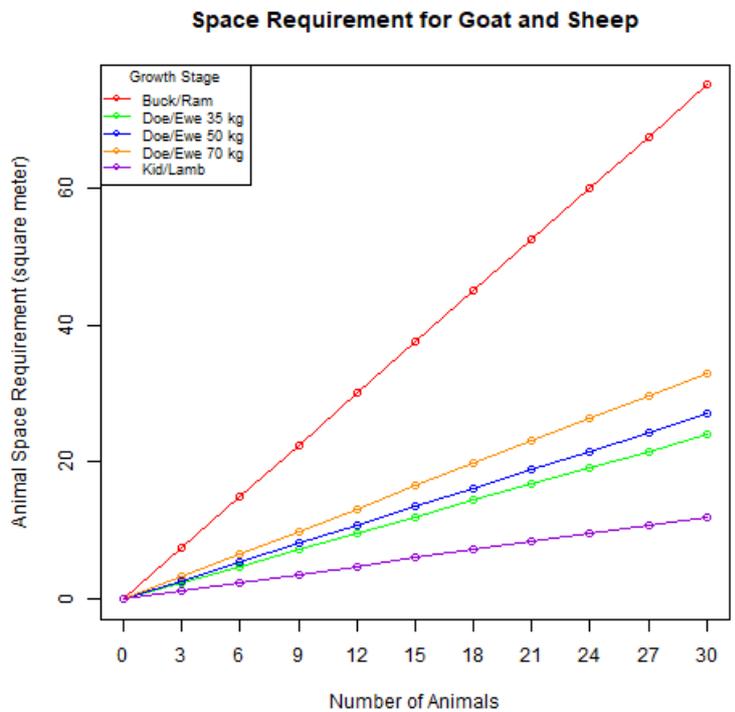


Figure 4b. Space Requirement for Goat and Sheep of different growth stages on housing with Slotted Floor.

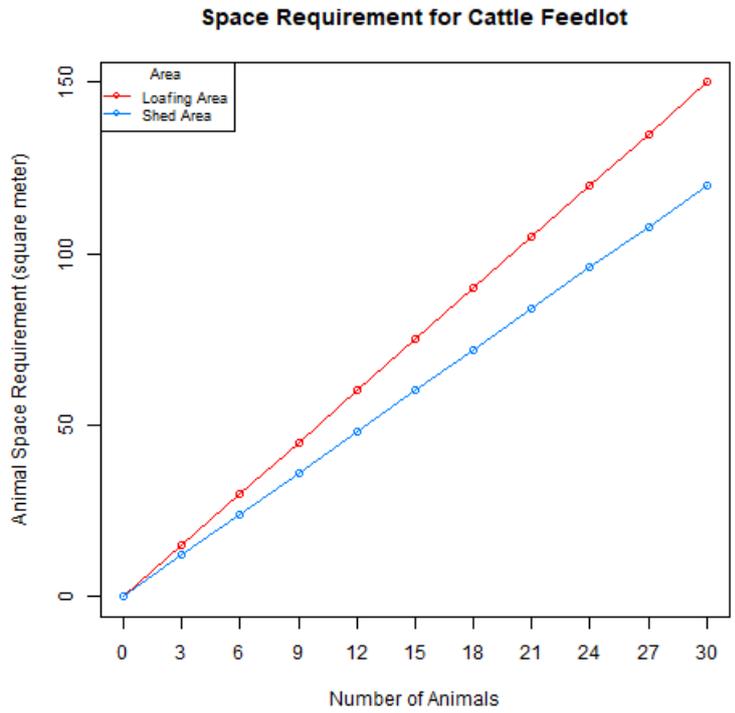


Figure 5. Space Requirement for Cattle Feedlot depending on the type of feedlot used.

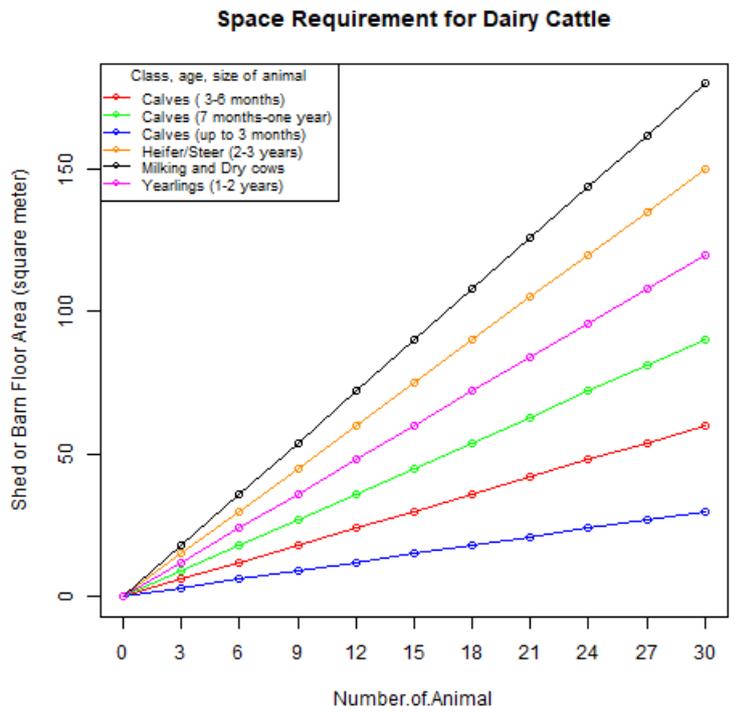


Figure 6. Space Requirement for Dairy Cattle of different class, age, and size.

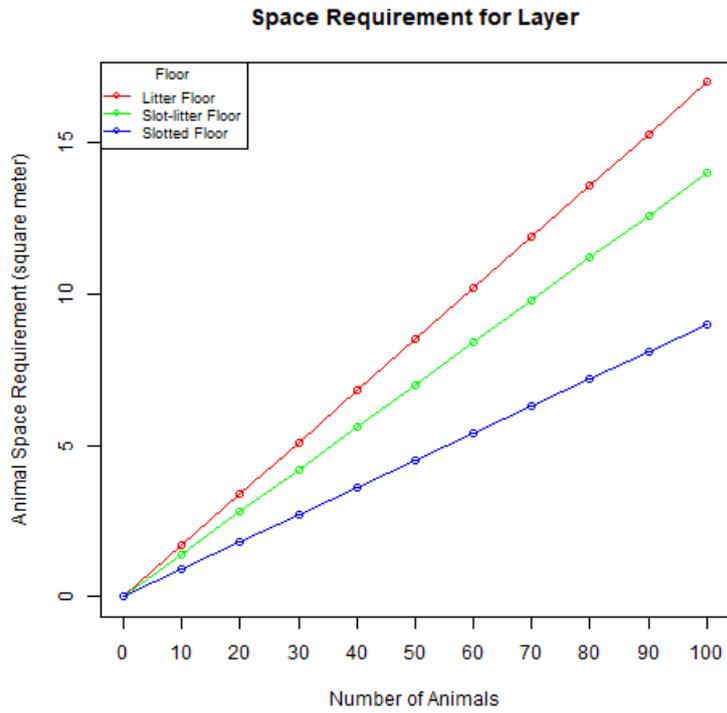


Figure 7. Space Requirement for Layer (beyond 22 weeks) using different type of flooring.

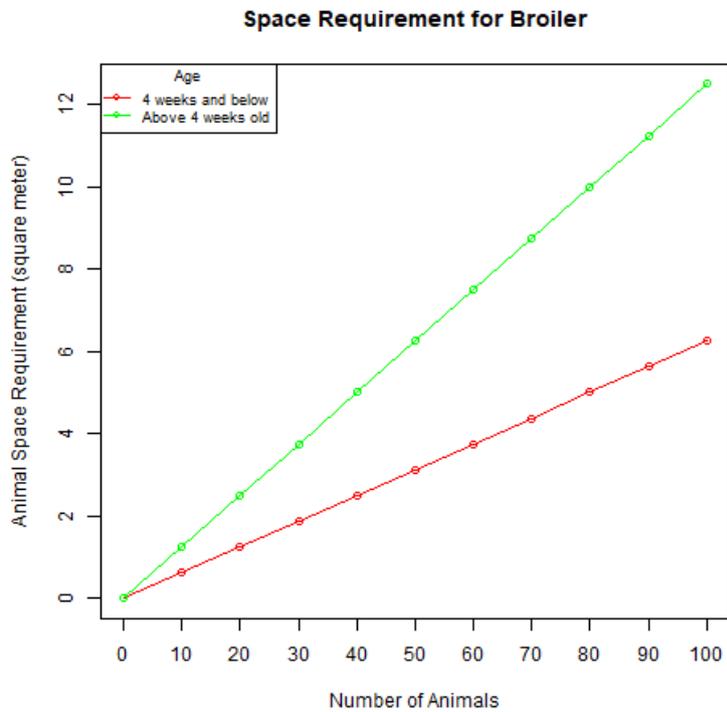


Figure 7. Space Requirement for Broiler for ages below 4 weeks to above 4 weeks old.

Conclusion

Satisfying the food demand resulting from population growth will require increased crop and animal production. Developing technologies that will inform and guide the producers is necessary. The developed technology, ASRC, and the graphs generated will be a helpful guide for livestock and poultry producers.

The authors have plans to upgrade the current tool. Future goals include additional animal scope; additional requirements on the facility, including feeder, waterer, lightning, ventilation; and calculation of feeding rate. Creating a web-based version is also being considered.

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