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LIVESTOCK PERFORMANCE UNDER CLIMATE CHANGE IN SUDAN: A STOCHASTIC SINGLE–MARKET MODEL

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INTRODUCTION

- The livestock sector plays a major and basic role in the economy of Sudan. The sector accounts for 15% of the GDP (Bank of Sudan).

- It satisfies all domestic consumption of animal products and contributes significantly for foreign exchange earnings through the export of life animal, meat hides and skin.

- Livestock are most prevalent in the rain-fed farming sector of Western, Central and Eastern Sudan where they are raised under nomadic and transhumance systems.

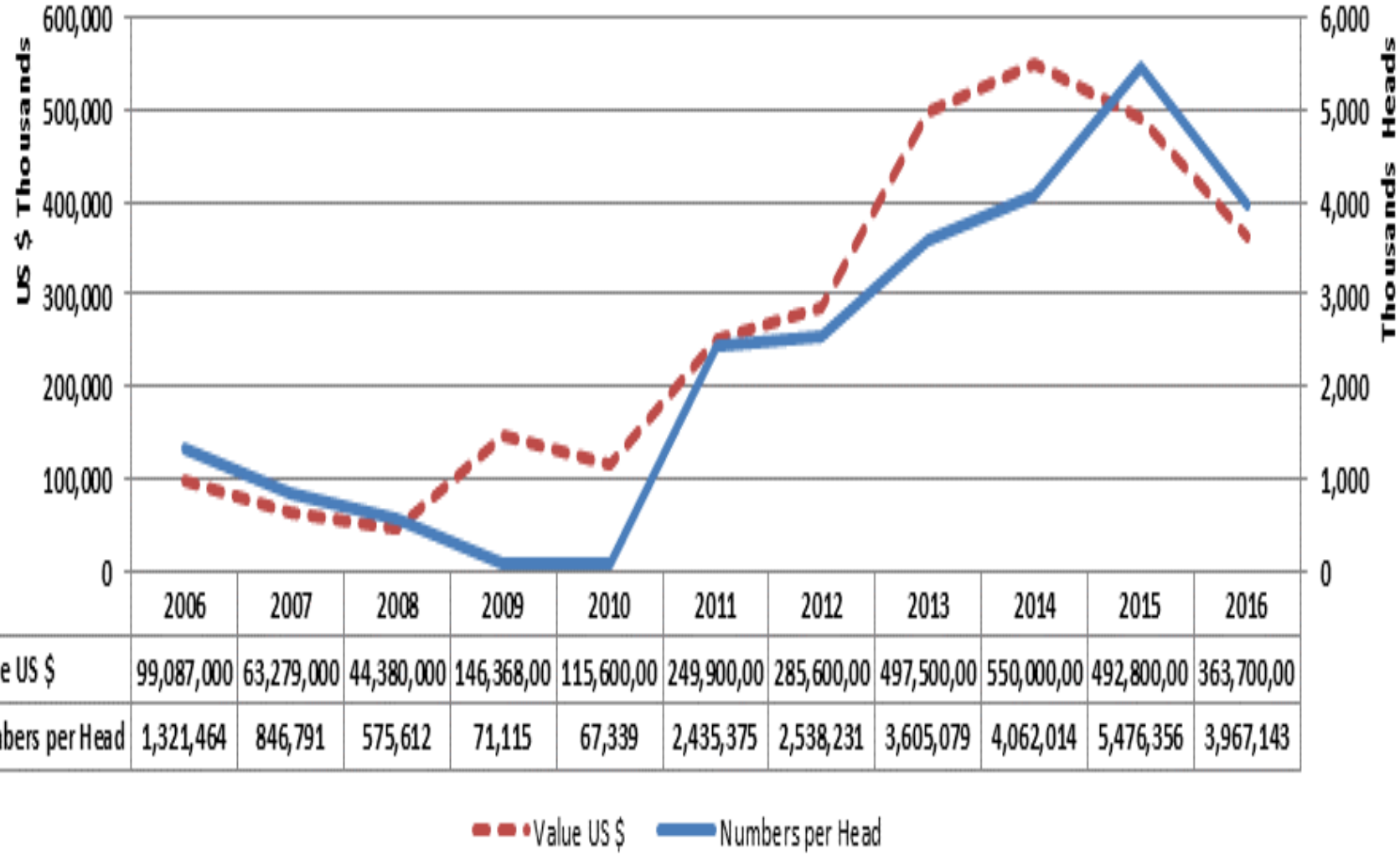
Table (1): Livestock numbers by type 2006-2016, Sudan

	Sheep	%	Cattle	%	Goat	%	Camels	%	Total
2006	50.390	36.5	40.994	29.7	42.756	30.934	4.078	3.0	138.218
2007	50.651	36.4	41.138	29.6	42.938	30.898	4.238	3.0	138.965
2008	51.067	36.5	41.426	29.6	43.104	30.788	4.406	3.1	140.003
2009	51.555	36.6	41.563	29.5	43.270	30.699	4.560	3.2	140.948
2010	52.079	36.7	41.761	29.4	43.441	30.613	4.623	3.3	141.904
2011	39.296	37.7	29.618	28.4	30.649	29.392	4.715	4.5	104.278
2012	39.483	37.6	29.840	28.4	30.837	29.393	4.751	4.5	104.911
2013	39.568	37.6	30.010	28.5	30.984	29.415	4.733	4.5	105.335
2014	39.846	37.6	30.191	28.5	31.029	29.312	4.792	4.5	105.858
2015	40.210	37.7	30.376	28.5	31.227	29.288	4.809	4.5	106.622
2016	40.612	37.8	30.632	28.5	31.481	29.270	4.850	4.5	107.555

Source: Bank of Sudan annual reports

Numbers in million head

Figure 1: Sheep export numbers and values, 2006-2016, Sudan



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Value US $	99,087,000	63,279,000	44,380,000	146,368,00	115,600,00	249,900,00	285,600,00	497,500,00	550,000,00	492,800,00	363,700,00
Numbers per Head	1,321,464	846,791	575,612	71,115	67,339	2,435,375	2,538,231	3,605,079	4,062,014	5,476,356	3,967,143

In tropical livestock unit (TLU) the biggest producers of livestock in Africa in 2011 were:

Ethiopia with 16% of the Africa's total stock (in TLU) ,

followed by Sudan (former) (11.3%),

Nigeria with 8%,

Kenya (6.78%),

Tanzania (5.70%),

South Africa (4.38%)

Somalia(4.22%),

Niger (3.86%), Mali (3.76%), and Burkina Faso (3%).

These ten countries account for about 2/3 of the continent's total livestock (Yaméogo, *et al*, 2014).

STUDY OBJECTIVE

- The main objective of this study is to analyze the impact climate change and price variability on the livestock economic performance in Sudan.

METHODOLOGY

- For this analysis, a stochastic single-market model has been developed. The model consists of supply and demand equations; rainfall is incorporated as an environmental element in the supply equation.

- The model has been extended to incorporate trade and national food security indicators which are based on the supply and demand equations of livestock.

- The supply and demand equations are represented by iso-elastic (Cobb-Douglas) function in which the price and income and rainfall elasticities are constant (Kirschke and Jechlitschka, 2002).

2.1 The Supply Equation

The supply of Livestock (sheep) is assumed to be uncertain and represented by the quantity produced which is function of its own price and rainfall as a main environment variable. Supply quantities, prices and rainfall are considered as uncertain variables. The product supply equations represented as follows:

$$q_i^s = c_i * (p_i^s)^{\varepsilon_{ii}} * (R^r), \qquad (1)$$

2.2 The Demand Equation

On the other hand, the demanded (consumption) quantity of livestock is set to depend on its own price and the consumer per capita income. Demand and prices are considered as uncertain variables. So, the system of the demand function can be expressed as follows:

$$q_i^d = b_i * (p_i^c)^{\eta_{ii}} * I^{\mu_i}, \qquad (2)$$

2.3 Surplus/deficit

$$Surplus/deficit = q_{i-}^{s} q_i^d \qquad \textbf{(3)}$$

2.4 Foreign exchange:

$$Fex = (q_{i-}^{s} q_i^d) p_i^w \qquad (4)$$

2.5 Food Security Indicator

2.5.1 Self-sufficiency ratio (SSR)

$$SSR = \sum q_i^s / q_i^d \qquad (5)$$

SCENARIOS

- Two scenarios have been developed in order to simulate the impact of environmental change and price variability.
  - The first scenario simulates the past period of environment and prices and both are used as base to compare to other scenarios simulations.
  - The second scenario simulates livestock under climate change of rainfall with a decreasing trend of 20% and world price increase of 50%.
- In each scenario, production and prices and rainfall were presented in their stochastic form

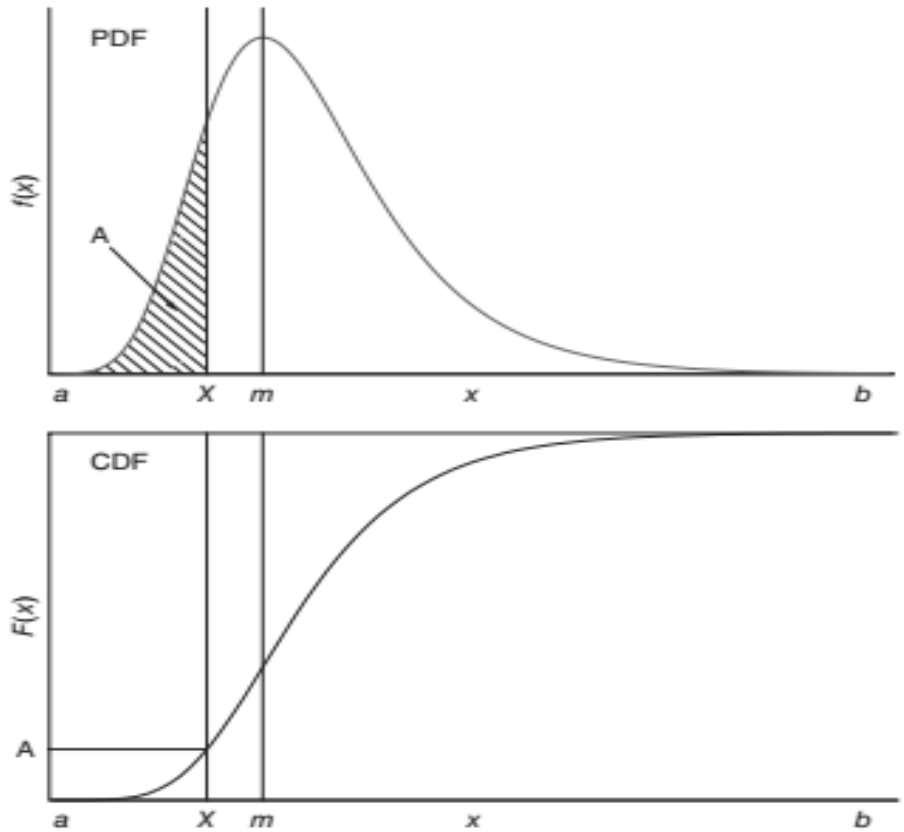
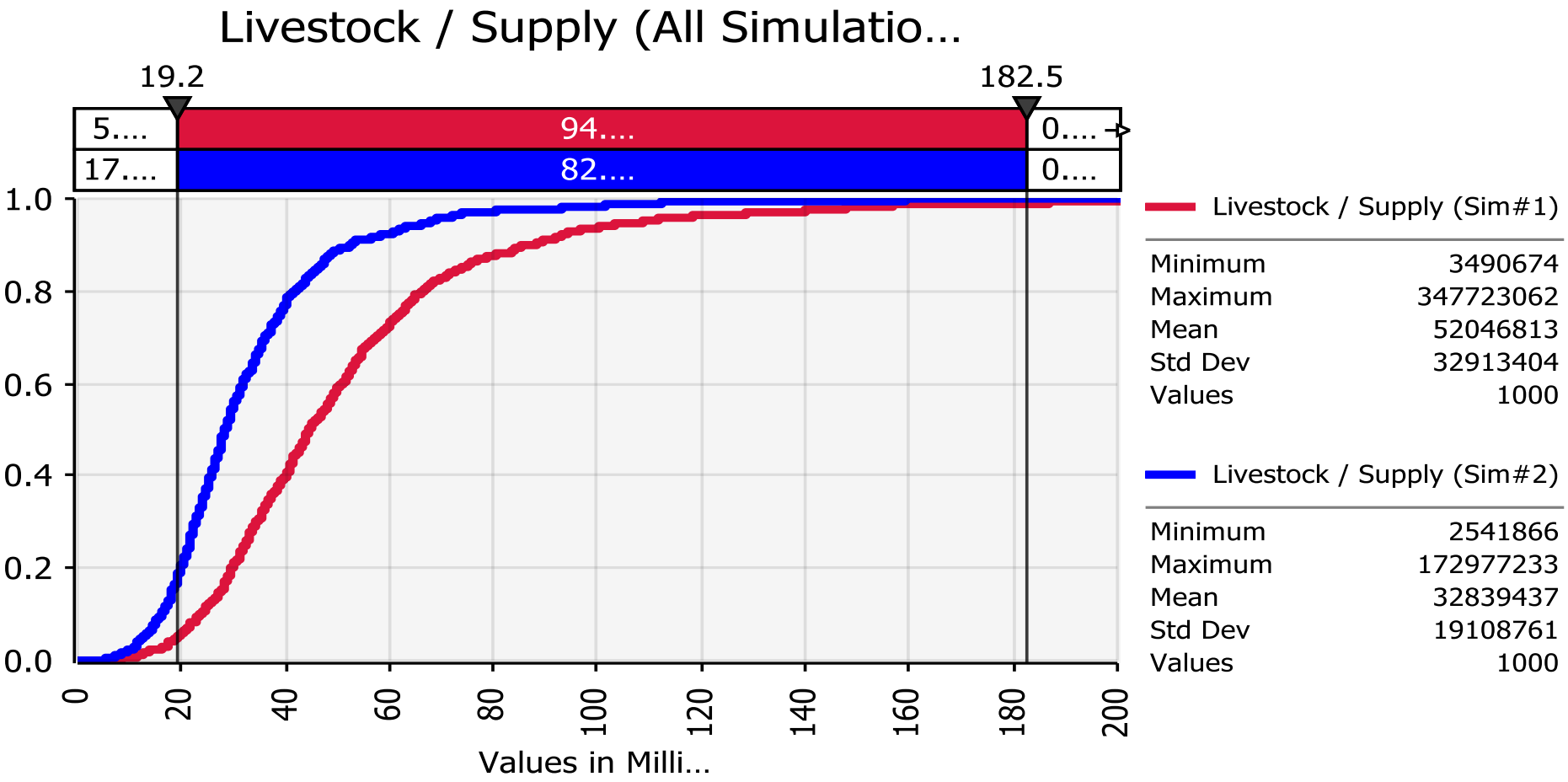


Fig. 3.7. The relationship between a probability density function (PDF) and a cumulative distribution function (CDF).

See: Brian Hardaker *et al* , Coping with Risk in Agriculture

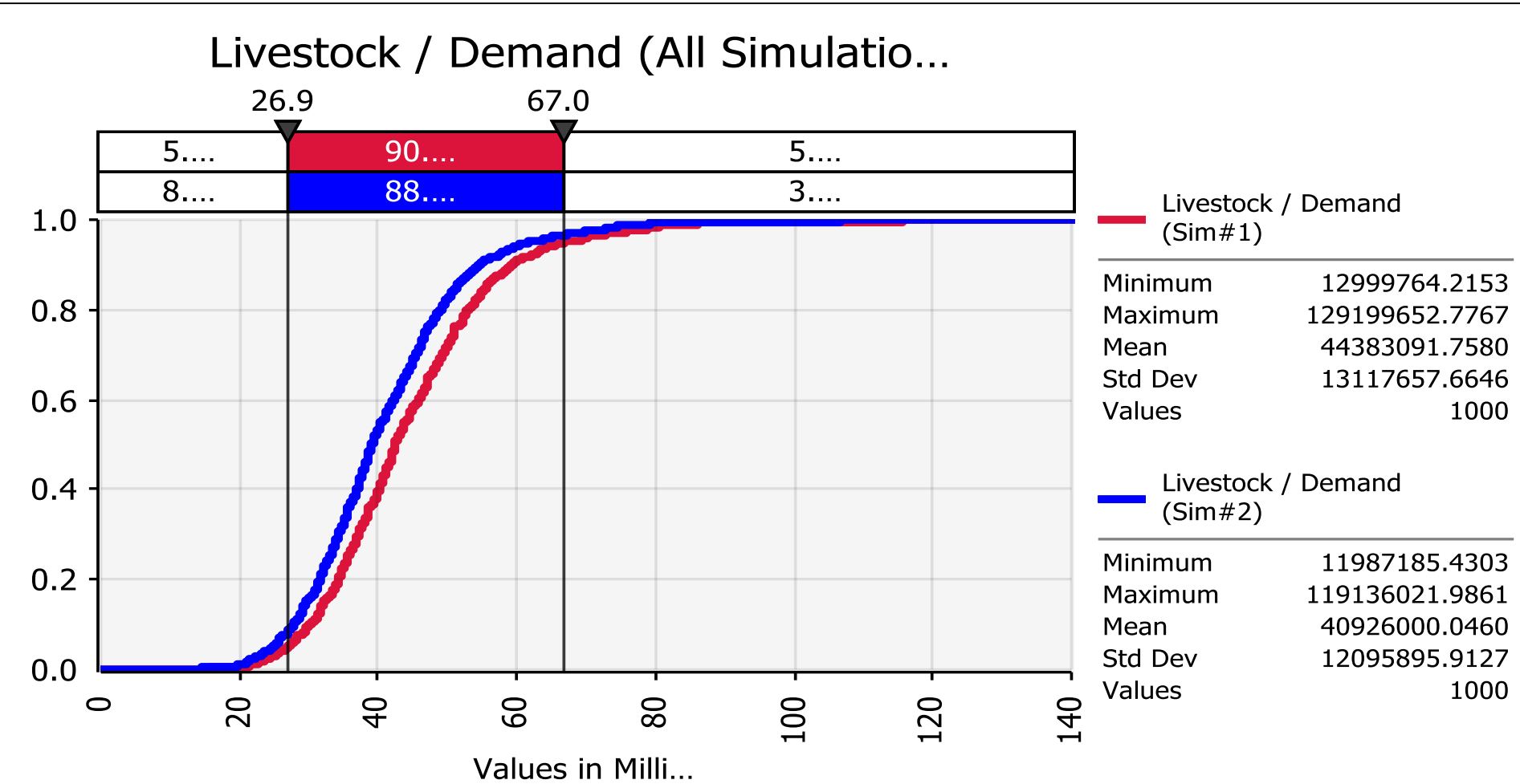
The Supply Effect

Figure (2): The *CDF* distribution of livestock supply, under the two scenarios



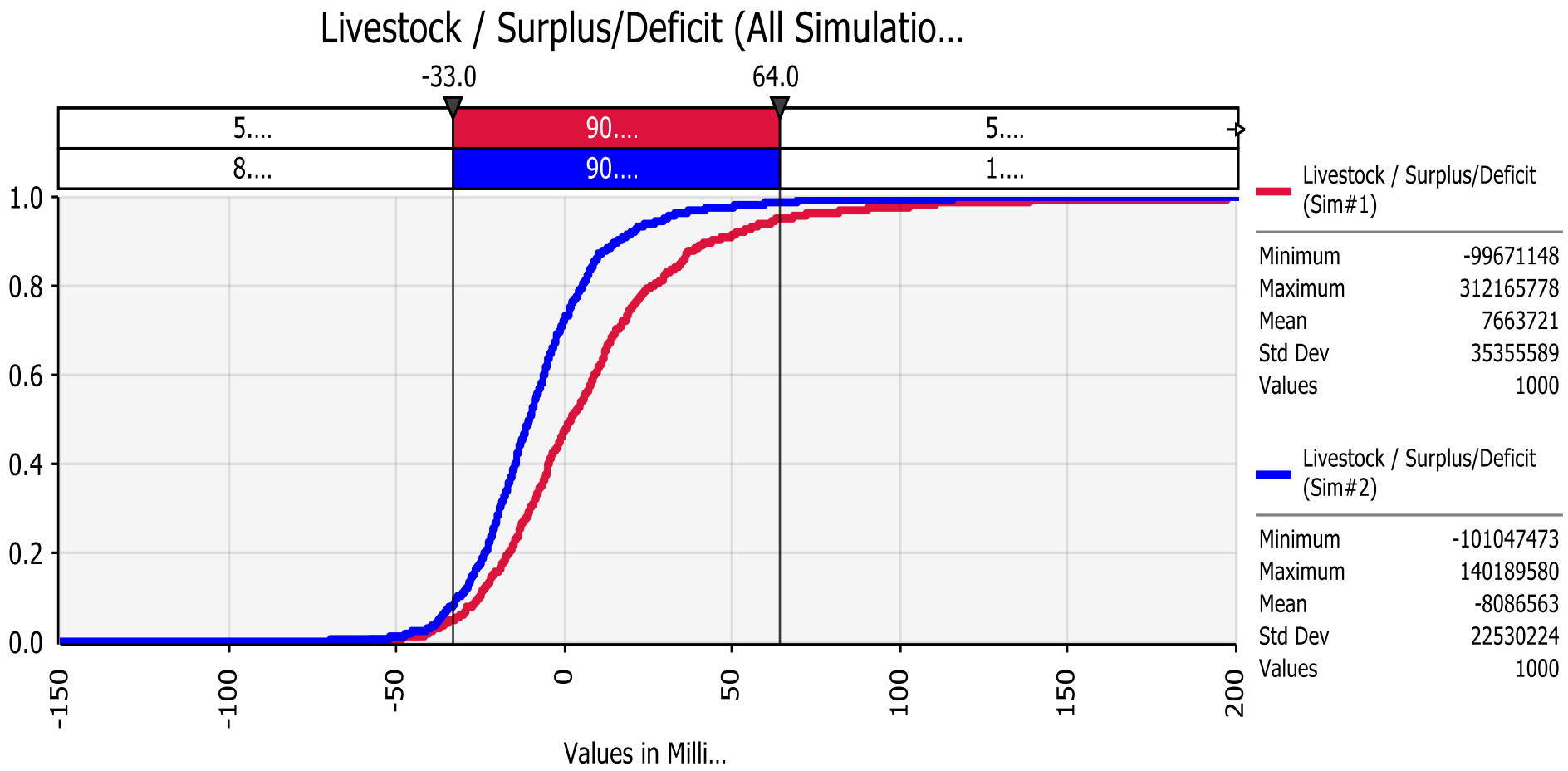
The Demand Effect

Figure (3): The *CDF* distribution of livestock demand, under the two scenarios



The Surplus-Deficit Effect

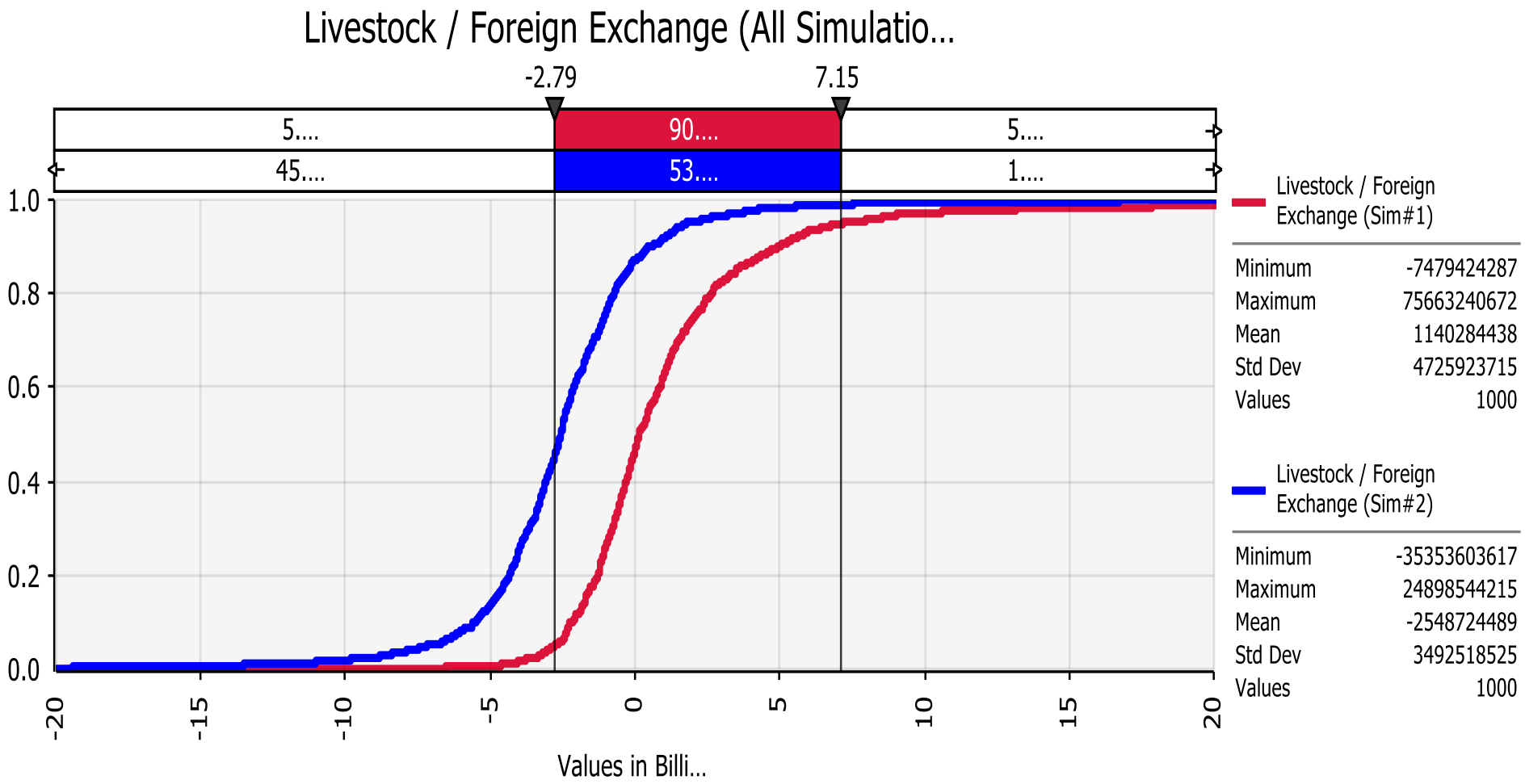
Figure (4): The *CDF* distribution of livestock surplus and deficit, under the two scenarios



CDF 0.6 CDF 0.52

Effect on Foreign Exchange

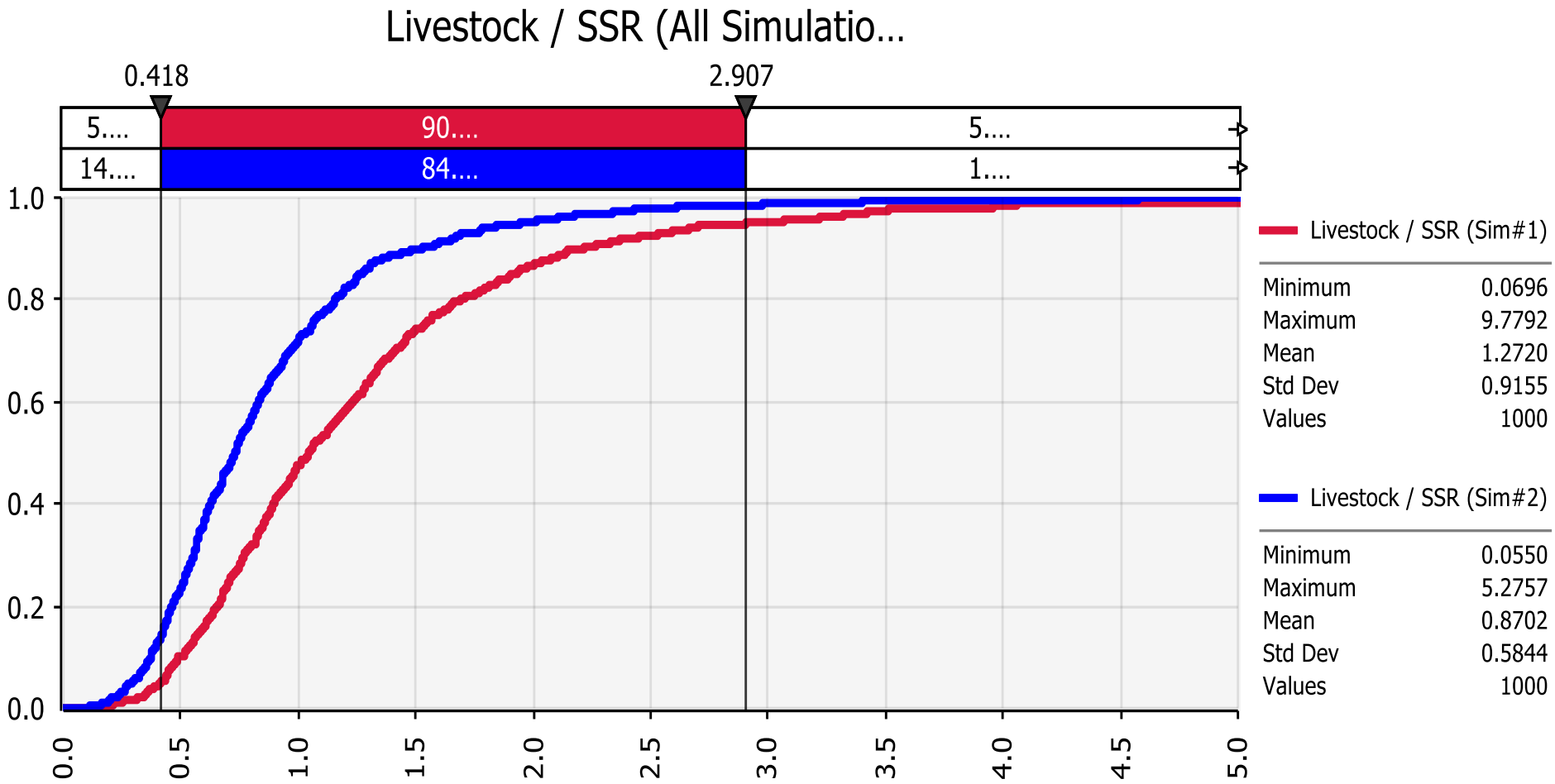
Figure (5): The *CDF* distribution of livestock foreign exchange, under the two scenarios



CDF 0.6 CDF 0.4

Effect On self-sufficiency

Figure (6): The *CDF* distribution of livestock SSR, under the two scenarios



CONCLUSION AND RECOMMENDATIONS

- The simulation results of climatic changes of reducing rainfall trend and price variability show a significant decrease in the livestock supply and demand

- Reflect a deficit of livestock balance to reduce the mean of SSR from 1.27 to 0.87.

- Under climate change, the country might be obliged to import around 8.086 million heads at US $ 2.548 billion on average to cover the deficit.

- The country needs to adopt climate adaptation and mitigation strategies to maintain its national herd.

- It is also recommended to expand livestock production in the irrigated sector and apply modern production technologies in order to increase livestock supply.

THANK YOU