Extended Abstract
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Paper/Poster Title	Mathematical programming for integrated smallholder farm management in Northeast Region of Nigeria.

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Abstract	200 words max

Smallholder farmers supply over 80% of food consumed in Nigeria. However, they face many challenges, particularly socio-economic constraints and uncertainty associated with variability in yields and prices. In the last ten years, the activities of insurgents have also posed a concern to the personal safety of farmers in the north-east region of Nigeria. Together, these challenges have affected farmers' ability to manage their land.

Therefore, building on the earlier optimisation framework of Peter (2019), this research uses a mathematical modelling approach that captures two main elements of the problem that farmers' face: their constraint boundaries and the uncertainty of production and market environments. Models used build on survey data, collected in 2019 and 2021, and reflect the land, labour, capital and social constraints faced by farmers. Crop Gross Margins (output value less Variable Costs of production) were constructed for different farm situations; uncertainty is captured through covariance matrices that reflect both real data and postulated relationships between prices and yields for different crops. We determine theoretically optimal farm plans at different levels of overall (farm) uncertainty through EV (Expected Value) Analysis. Acts of 'insurgency' were incorporated into the uncertainty framework (for example, through the effect of theft on crop production under different assumptions).

Keywords	Mathematical programming, Smallholder farmers, Risk
JEL Code	Agricultural commodities Q22 see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	100 – 250 words

The Nigerian Agricultural sector employs over 70% of the working populace and 88% of these are small scale farmers (Babura et al., 2017; Akujuru, 2015; Gokmenoglu, et al.,2016). The northern region of Nigeria accounts for 67% of the smallholder farmers producing over 80% of the major staple foods consumed in the country, the bulk of these are cultivated in the northeast region (Maurice et al., 2015. Nonetheless, it has been reported that 72% of the Nigerian smallholders' farmers are living below the poverty line of USD 1.9 a day and 25.6 million Nigerians, mostly farmers, are undernourished due to challenges confronting their farming activities (FAO, 2018; WFP., 2020). Previous studies have focused on fragmented challenges facing the smallholder farmers such as land tenure system, lack of capital, poor government policies, lack of modern facilities and ineffective markets (Ojo et al., 2012; Samberg et al., 2016; Abdul et al., 2017; Obi and Ayodeji, 2020). Peter (2019) recently identified and reported challenges faced by smallholder farmers in the Northeast region of Nigeria from a profit maximisation perspective.

Consequently, with risk becoming more burdensome to farmers, not least because of the insurgency in Northeast Nigeria that has destabilised incomes and affected farmers' ability to sustain household food security, this study uses survey data from 2021 and a novel modelling approach that builds on the work of Peter (2019).

Methodology	*100 – 250 words*

The study area is the Agricultural zone IV of Adamawa state, Northeast Nigeria. With the aid of a structured questionnaire, data were collected in October 2021 from a sample of 120 farmers. Two local government areas were selected based on accessibility. Five villages with a dense population of farmers were selected from each area. A total of one hundred and twenty (120) farmers were randomly selected from the list of registered farmers on a proportionate percentage from the ten farming villages. The questionnaire was designed to capture the elements of the farming systems in the region; in particular farmers' objectives, resource use and availability, expected and realised prices, expected and realised yields and farmers' assessment of the variability of prices and yields.

Mathematical programming was used to model constraint boundaries and the uncertainty of production and market environments. Using survey the data, crop Gross Margins (output value less Variable Costs of production) were constructed for different farm situations; uncertainty was captured through covariance matrices that reflect both real data and postulated relationships between prices and yields for different crops. We determine theoretically optimal farm plans at different levels of overall (farm) uncertainty through EV (Expected Value) Analysis. Acts of 'insurgency' were incorporated into the uncertainty framework (for example, through the effect of theft on crop production under different assumptions).

Results	*100 – 250 words*

The work is ongoing but results will show the effect of changes in farm management on i) profitability; and ii) risk, as measured by farm system variability of income. Insurgency effects will be captured using the same framework.

Discussion and Conclusion	*100 – 250 words*

This section will be pending until result and discussion have taken place.