The role of seed-aid in a protracted crisis context
A localization strategy from South Sudan

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Abstract [227 words]:

Maize productivity in South Sudan is the lowest in East Africa. Such a yield-gap is persisting despite 15 years of seed-aid distribution by humanitarian agencies, to help farmers produce in the presence of recurrent conflicts. This is so because seed-aid has largely consisted of low-yielding varieties imported from Uganda and the rest of the region, and has culminated into a seed monopoly. The development of a domestic seed market is necessary to introduce higher-yielding varieties that are better adapted to local preferences and agro-ecological conditions. However, the constraints to the development of a seed market in a protracted crisis context are not well understood. For this study we organized a seed fair in which domestic SMEs could sell their seeds directly to local farmers who were randomly provided with transportation incentives to participate in the fair, as well as with technical information concerning the seeds on sale. Our results indicate that average maize productivity increased significantly for those farmers that participated in the fair. However, only a few farmers ended up buying seeds at the fair, as South Sudanese farmers appear to be generally reluctant to pay for seeds. Drawing on these findings, we facilitated a multi-stakeholder consultation process that emphasized the need to improve (rather than cut) seed-aid distribution, by enabling and compelling humanitarian agencies to procure more and better seeds from within South Sudan.

Keywords:

Smallholder farmers; agricultural productivity; seed-market; seed-aid; randomized control trial (RCT); science-policy interface (SPI); localization strategy; South Sudan; Africa.

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1. Introduction

South Sudan is a young and fragile country with a huge but largely untapped agricultural potential. The country's short history is rife with political conflicts and humanitarian emergencies. Since its independence in 2011 South Sudan has received the equivalent of approximately one billion USD in imported seed-aid, and yet the country's agricultural productivity remains among the lowest in the East African region (Smits et al., 2024; AGRA 2021). The distribution of free seeds to farmers is a very popular intervention in South Sudan, like in most other fragile countries worldwide, because seed-aid has the potential to simultaneously reduce food insecurity and dependency on food-aid (Sperling and McGuire, 2010). However, this conventional *thesis* is increasingly contested by both stakeholders and researchers, who describe seed-aid as a problem rather than a solution for South Sudan's agricultural growth. In particular, Smits et al. (2024) stresses that seed aid distribution in South Sudan has largely consisted of low-yielding seeds imported from Uganda and the rest of the region, and has culminated in a state-endorsed monopoly for seed supply, which has also contributed to minimize diversity in the genetic pool of local varieties.

Hence, the first question we address in the remainder of this study is whether it is time to start cutting down on seed-aid distribution in South Sudan, and re-allocate seed-aid funding to support the development of a domestic seed-market. Still, the constraints to seed market development in a protracted crisis context are not well understood and generally understudied (Sperling & McGuire 2010). Therefore, in this paper we analyze the *antithesis* that South Sudan could indeed benefit from the re-purposing of foreign development assistance towards the creation of a domestic seed market. Finally, we try to understand why this is not happening. In particular, our analysis is based on a Randomized Control Trial (RCT), which we set-up in the context of a local seed-fair. Such an experimental fair allowed us to assess the impact of an artificially created seed-market, on the maize yields of local farmers. The results indicate that seed-market development has indeed the potential to increase average maize productivity to a significant extent. However, only a few farmers bought seeds at the fair and secondary data also suggest that South Sudanese farmers are generally reluctant to pay for seeds.

The study concludes with a *synthesis* based on the deliberations that emerged from a Science-Policy Interface (SPI), which involved a multi-stakeholder consultation process that allowed us to translate our research findings into a broad-base strategy for the transformation of the South Sudanese seed system. In particular, the resulting strategy calls for all humanitarian agencies to procure more and better seeds locally, as a necessary stepping stone towards the development of a domestic seed-market. The ”localization” of seed-aid is envisaged as a strategy to overcome farmers' reluctance to pay for local and improved seeds and boost the country's agricultural productivity, whilst contributing to advance the development of the domestic seed industry. However, investments in seed quality control and certification are urgently needed to enable and compel humanitarian agencies to procure more and better seeds from within South Sudan.

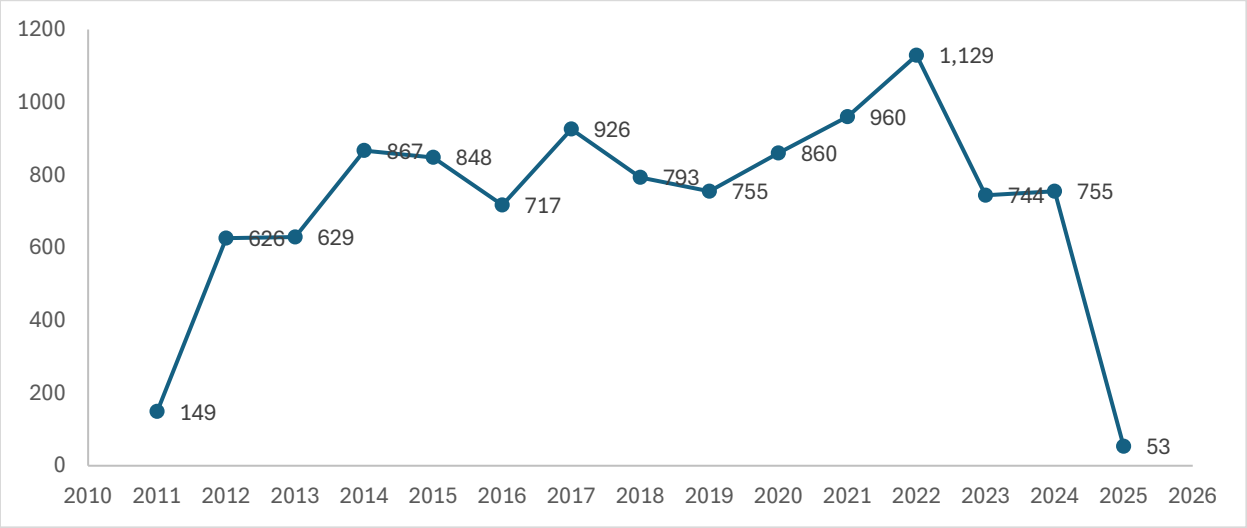
Overall, our *thesis-antithesis-synthesis* paradigm contributes to fill-in a few important gaps in the literature. The first and larger gap is the result of an extremely limited number of academic and empirical studies addressing issues related to agriculture in South Sudan. Our study also produces much needed evidence and recommendations about seed-aid distribution and seed-market development in a protracted crisis context. However, the following analysis has a few limitations that deserve to be acknowledged upfront. First, our RCT relies on a small sample size, comprising only 200 farm-households. Second, the deliberations that emerged from our SPI were produced during just one day, by a non-representative group of 70 stakeholders. By no means can the results and deliberations of these studies be therefore considered as definitive, they can only provide a basis for further research and policymaking efforts.

2. Background

Since its secession from Sudan in 2011, South Sudan has been plagued by political instability and slow economic and infrastructural development. These conditions have fueled internal conflicts in many parts of the country, though some stability was achieved with the 2018 peace agreement and the formation of a unified government in 2020. Oil

extraction has been the country's main source of income since independence, accounting for approximately 60 percent of the gross domestic product (AFDB, 2013). However, the oil pipeline for export, which flows through Sudan, was damaged during the Sudanese civil war in 2024. International donor agencies, with USAID at the forefront, have also been major sources of capital for South Sudan. The total value of the official development assistance provided by the United States alone to South Sudan in 2024 was estimated at 755 million USD, corresponding to about 25 percent of the gross national income (Figure 2). But in January 2025 the overall contribution of U.S. to the economy of South Sudan was suddenly and indefinitely put on hold, as a result of the stop-work order by the Trump administration. Following the withdrawal of U.S. support, in March 2025 South Sudan witnessed a resurgence in both social and political conflicts.

Figure 1. U.S. official development assistance to South Sudan (in million US$)[2]



Today the country is among the poorest in the world, with a projected GDP per capita for 2025 of 960 USD at purchasing power parity, falling from USD 1,105 in 2011 (IMF, 2025). Real

[2] Source: ForeignAssistance.gov
https://foreignassistance.gov/cd/south%20sudan/2011/obligations/0

GDP growth fell drastically right after independence and has bounced sideways for many years. Although real GDP growth for 2025 is projected to be 27 percent, this is mostly attributable to recovery in oil export resulting from the reparation of the pipeline (IMF, 2024-25). Most importantly, in 2024 WFP estimated that 73 percent of the 12 million people living in the country required humanitarian assistance, while an estimated 7.1 million faced food insecurity (WFP, 2024). Additionally, the country is home to over half a million refugees, mostly from Sudan, and over two million South Sudanese are estimated to be displaced, both externally (mostly in Uganda) and internally (WFP, 2024).

Agriculture, the second most important sector of the economy, remains exceptionally underdeveloped, even if it appears to be the primary source of livelihood for 70 percent of the population (MAFS, 2023). South Sudan has great potential for agricultural development, given that 75 percent of the land area is suitable for agriculture, of which only 5 percent is currently exploited for that purpose (MAFS, 2023). The country has diverse agro-ecological zones that can support a wide cropping portfolio (MAFS, 2023). Maize is the primary staple crop in South Sudan and is therefore essential for both food security and income generation purposes (Awata et al., 2021). However, average maize yields in the country range between 0.3 and 0.9 tons per hectare, which are significantly below the average yields reported from Uganda, Kenya, and Ethiopia (Awata et al., 2021).

a. Seed-aid

The inability to deliver quality seeds at the right place and time is considered to be one of the greatest limiting factors to agricultural development in South Sudan (Bear and Zulfiqar, 2023). So far the country's seed system has been dominated by FAO and various humanitarian agencies, which procure large quantities of seeds from neighboring countries, especially from Uganda, and re-distribute them for free throughout South Sudan (Smits et al., 2024). Though seed-aid agencies have policies on solely procuring certified seeds, or seeds whose quality is certified in the country of origin, the absence of institutional regulations or quality checks for seeds within South Sudan opens up to the inflow of damaged seeds, which are transported over long distances and under extreme climatic and poor storage conditions (AGRA 2021). In addition to this, seed-aid consists mostly of seeds

that are poorly adapted to local preferences and conditions; as well as of second generation (F2) hybrid seeds, which are certified and cheap but extremely low-yielding, due to hybrid breakdown or inbreeding depression (which is the reason why F1 hybrid seeds need to be re-purchased before each planting season; AGRA 2021).

The distribution of free seeds to farmers is a very popular intervention in South Sudan like in most other fragile countries worldwide, because seed-aid has the potential to simultaneously reduce food insecurity and dependency on food-aid (Sperling and McGuire, 2010). The distribution of seed-aid involves many international agencies. FAO alone managed 400 seed-aid projects globally, between 2003 and 2005 (Sperling and McGuire, 2010). Seed aid distribution is a mainstream agricultural response during both the emergency and recovery phases of humanitarian relief (Sperling and McGuire, 2010). The main problem is that many humanitarian crises tend to endure over the medium or even long term, de facto becoming chronic crisis (like in South Sudan), and therefore seed aid distribution tends to be repeated year after year, under a general lack of scrutiny and with little apparent benefits (Sperling and McGuire, 2010; CIAT and FAO, 2011). More in general, there is growing consensus among researchers that humanitarian aid makes sense only for short-term relief, and if it is continued for too long it can create dependency and crowd-out opportunities for the development of domestic industries and markets (Tripp and Rohrback, 2001; Lie, 2020; Uneze, 2020; Rai et al., 2024).

In addition to free and imported seed varieties, South Sudanese farmers use locally recycled seeds that are often originating from the same varieties that are introduced by humanitarian agencies (FAO et al., 2019; Awata et al., 2021). As a result, the pool of seed varieties available within South Sudan appears to be rather limited or homogenous and inadequate to address persisting yield gaps. To this point, Smits et al. (2024) demonstrate that maize yields do not increase when farmers use seed-aid, in addition to locally recycled varieties. In particular, using a primary dataset on almost 2,000 farm-households from the green belt (or southern/equatorial states) of South-Sudan, these authors estimate that almost a third of farm-households had received seed-aid during 2021, and that the adoption of these imported and free seeds did not result in any detectable increase in maize yields per hectare,

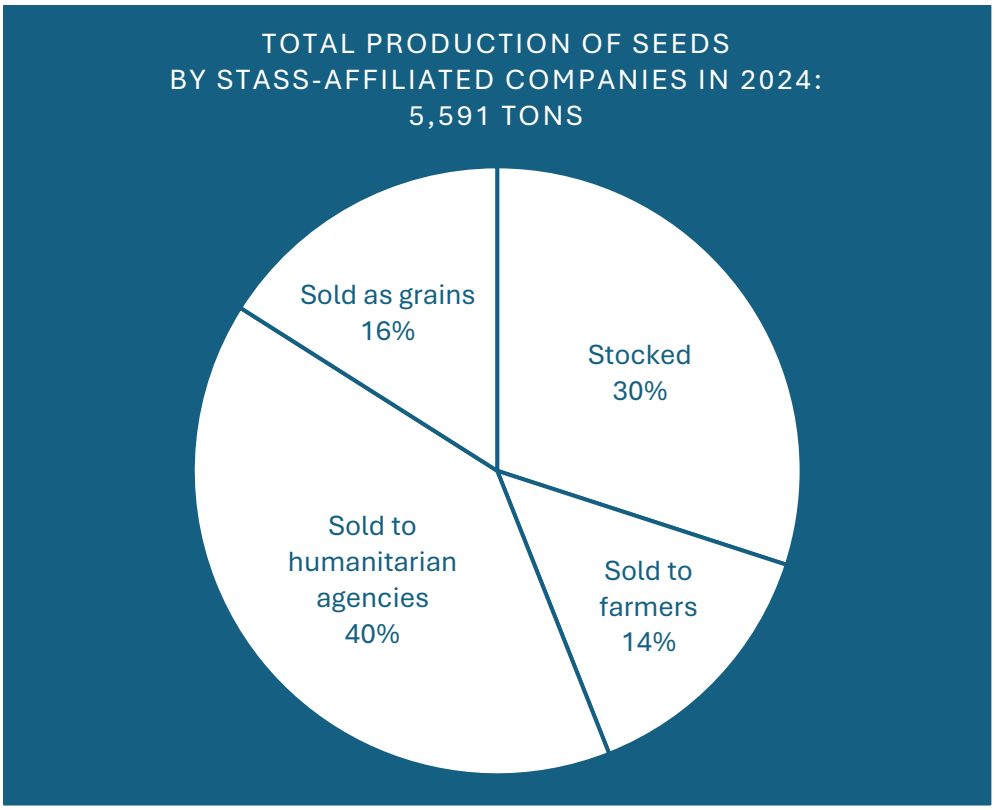
nor in the amount of land cultivated with maize. Even if seed aid distribution could be still justified above the green belt, where conflicts are more frequent and intense, and where farmers are more likely to be seed-deprived, it seems obvious that agricultural growth in South Sudan hinges on the development of a domestic seed market.

b. Seed-market

Over the past decade, the Embassy of the Kingdom of the Netherlands (EKN) has financed two consecutive projects implemented by AGRA and IFDC, to promote the development of a South Sudanese private seed sector. As a result, the country today counts a dozen small and medium seed producing and trading companies that are owned by South Sudanese entrepreneurs and affiliated with the Seed Trade Association of South Sudan (STASS). These companies are producing and commercializing only open-pollinated seed varieties (OPVs), which are however claimed to be significantly higher-yielding than those recycled or received for free by farmers. Although a few STASS-affiliated companies are also working towards the introduction of F1 hybrid varieties, only a negligible amount of these seeds had been introduced by the time we concluded this study. (IFDC, 2024).

As depicted in Figure 2, in 2024 a total of 5,591 tons of seeds were produced by STASS-affiliated seed companies, who worked with 1,461 seed out-growers (or seed multipliers, comprising mostly smallholder farmers). Of this total seed production, 70 percent (or 3,936 tons) was eventually sold, while the rest was stocked (to be sold in 2025). Only 756 tons of seeds were sold directly to farmers, corresponding to 14 percent of the total amount of seeds produced in 2024. The majority (40 percent) of seeds produced in 2024, equivalent to 2,260 tons, were sold to humanitarian agencies involved in the distribution of seed-aid. Finally, the remainder (20 tons) of the seeds sold by STASS-affiliated companies were actually marketed as grains, at a significantly lower price, due to the absence of seed buyers and the need to pay-off seed out-growers. (IFDC, 2024)

Figure 2: domestic production and commercialization of seeds in South Sudan [3]

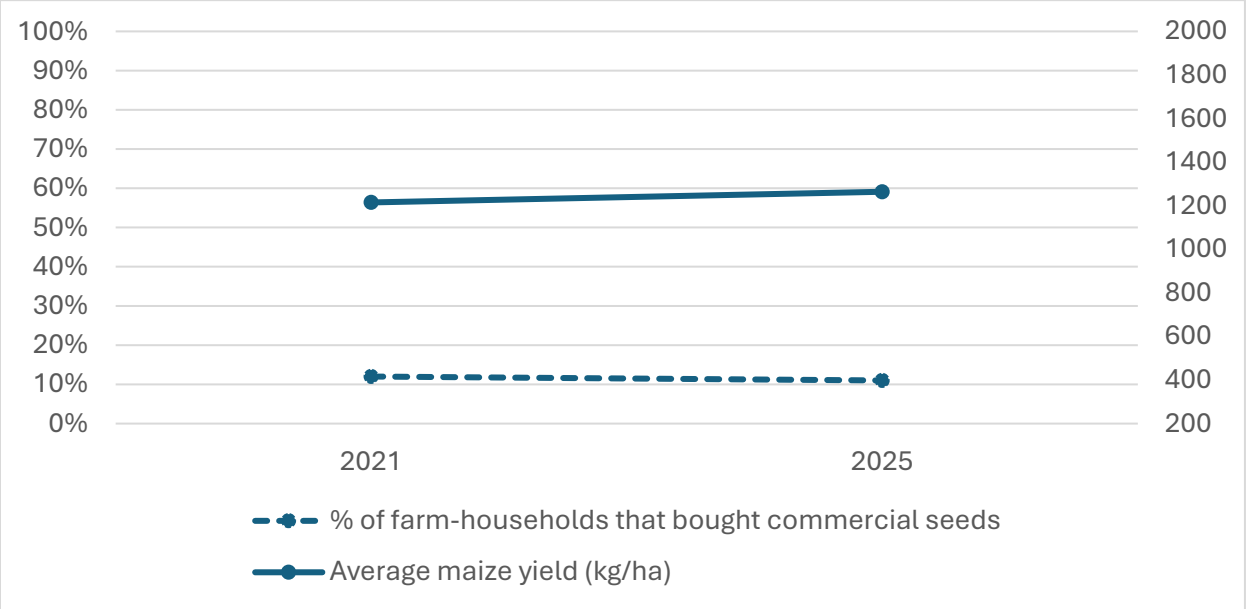


Overall, this secondary evidence suggests that the seed-market of South Sudan is still at an embryonic stage of development. This conclusion is supported by the panel data described in Figure 2, which show that commercial seeds have been consistently procured by no more than 11-12 percent of the 1,500 farm-households surveyed by KIT and IFDC between 2021 and 2025, across the green belt of South Sudan (KIT and IFDC 2025). Instead of investing in the development of last-mile marketing networks to sell their seeds to farmers, domestic seed companies prefer to sell their seeds in bulk to humanitarian agencies. Still, the quantity sold to humanitarian agencies in 2024 accounted for just 20 percent of the total amount of seeds procured by FAO alone (estimated at >10,000 tons; IFDC 2024). This is because humanitarian agencies continue to favor certified seeds from abroad, for local seeds cannot be possibly certified, due to the absence of a seed quality control and certification system

[3] Source: A3SEED project annual report for 2024, by IFDC-South Sudan.

within South Sudan (KIT and IFDC 2025). And as domestic seed companies struggled to find either private or institutional buyers, average crop productivity remained stagnant between 2021 and 2025, among the 1,550 farm-households surveyed by KIT and IFDC across the green belt (Figure 2).

Figure 2. Stagnation in seed marketing and maize productivity between 2021-25, across the green belt of South Sudan (sample: 1,500 farm-households)[4]



3. Randomized Control Trial

Conventional wisdom in South Sudan supports the re-purposing of the large financial resources that are currently spent on seed-aid to promote the development of a domestic seed-market. However, initiatives to facilitate free exchanges among seed suppliers and buyers in South Sudan do not seem to be gaining enough traction to justify significant cuts to seed-aid distribution. This is because the impact attributable to seed-market

[4] A3SEED internal project evaluation (2025), KIT and IFDC

development initiatives, and their underlying constraints remain unclear. To address these knowledge gaps, we analyzed the impact of a seed-fair organized by IFDC right before the beginning of the planting season, in March 2023, in Magwi County (Eastern Equatoria state). The purpose of the fair was to bring together a critical mass of seed buyers and suppliers in one place and for a day, to promote and facilitate market-based seed exchanges. The seed suppliers that agreed to participate included five domestic seed companies affiliated with STASS, which received full sponsorship by IFDC to participate in the fair.[5] STASS-affiliated companies were the only suppliers invited to the fair, as a way to minimize sales of unknown, imported and poor quality seeds.

Participation in the fair was, however, open to all potential seed buyers and free of charge. Announcements were made via the radio before the fair, to promote participation by as many potential buyers as possible, especially among local farmers. In addition to public announcements, 100 local farmers were randomly selected and provided with encouragement packages to attend the fair and buy seeds. These packages included: i) a personal invitation in the form of a flyer delivered at home, containing information about the improved attributes and expected yield-gains associated with the seeds sold at the fair; ii) in-cash reimbursement of transportation costs to attend the fair (to be received at the end of the fair); and iii) an additional invitation to attend a training session the morning before the fair, to learn more about the improved attributes and expected yield-gains associated with the seeds sold at the fair, as well as suitable farming practices.

The farmers who received the encouragement packages constituted our treatment group. Similarly, another cohort of 100 local farmers were randomly selected into our control group, which received no encouragement to participate. The randomization of treatment and control farmers was based on data collected in fall 2021 by Smits et al. (2024) on almost 2,000 maize farm-households from the Western, Central and Eastern Equatoria states. Out of this sample, 717 households were located in Magwi county and provided the sub-sample from which we randomly selected treatment and control farmers. At the end of 2023, we

[5] The representatives of five seed companies (Afroganics, Seed Grow, Masco, Gumbo Glow, and Green Horizon), plus six of their agro-dealers participated in the fair.

retraced and re-surveyed the 200 farmers assigned to both groups, and assessed eventual differences in maize yields. Since the seed-fair was publicly announced via the radio, and participation was open and free, our RCT fully complied with the basic ethical principle of non-exclusion (Barret and Carter 2010-2020). Still, given the high conflict context in which we organized the RCT, we sought and obtained in-country ethical approvals well before the seed-fair took place, from the Relief and Rehabilitation Commission, as well as from relevant federal, state and county level authorities concerned with research ethics, data governance and civil security.

Open and free participation also meant that both treatment and control farmers, as well as anybody else could access and purchase the seeds offered at the fair, which were sold at market price, without any interference by third parties. As a result, the seed-fair provided an ideal experimental setting to assess the impact and constraints associated with seed market development interventions, and it was ultimately attended by a total of 747 local farmers. The transactions that took place during the fair involved sorghum, groundnut and vegetable seeds, as well as maize. In particular, a total of almost 400 kg of maize seed was sold during the fair, which was deemed sufficient to cultivate just 20 hectares of land. Even smaller quantities of sorghum, groundnut and vegetable seeds were also sold during the fair.

a. Data

Because of the instability that characterizes South Sudan, we were confronted with some sampling attrition (or drop-outs), as 16 treatment farmers out of the original 100 could not be retraced and one control farmer refused to be interviewed at the end of 2023. As a result, our final sample comprised 183 farm-households, of which 84 belonged to the treatment group and 99 to the control group, with all these farm-households having provided data corresponding to both the 2021 and 2023 main (or first) agricultural seasons. Therefore, in the following analysis we consider the data collected in 2021 as our baseline, and the data collected from the same households in 2023 as our endline, which together provides the panel dataset used for this analysis.

Our power calculations revealed that this sample size required a minimum detectable effect size of 196 kg/ha, in terms of increased maize yield, which is equivalent to a productivity increase of 40% compared to baseline mean value. This power calculation used the average baseline maize productivity (493) and standard deviation (471), as well as alpha (0.05), power (0.8), treatment group size (84) and control group size (99). Even if the minimum detectable effect size appeared quite large, we decided to proceed with the RCT, given that the seed fair was going to be organized anyway; average maize productivity at baseline was extremely low; and the expected productivity gains resulting from the procurement of local and improved seeds were also expected to be large.

To properly isolate the impact of the seed-fair – as a proxy for a seed-market development intervention – on maize productivity, we first needed to ensure that our randomization was successful, or that no hidden selection bias determined the assignment of farm-households to treatment and control groups. We assess our randomization via balancing tests on baseline observable characteristics, to ensure that there is no statistically significant difference between the two groups, which would violate their comparability (Altman, 1985). Table 1 shows that we have a good balance between control and treatment households at baseline (2021), across all categories of observables, as no significant differences emerged.

On average, 32 percent of the households were headed by women, while the average age of the household head was 38. Approximately 44 percent of households' heads had obtained an education level above primary school. The average household size is estimated at eight people, half of which were children. The average annual income was 605 USD. The average land area owned was 3.4 hectares and the average land area cultivated was 4.2 hectares, split between two crops. The average maize yield from the first agricultural season of 2021 was slightly below 500 kg/ha.[6]

[6] The first planting season spans from March – May while harvest takes place in July and August.

Table 1: Sample demographics at baseline (2021) and balance tests

	Overall		Control (C)		Treatment (T)		C-T	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Difference	p-value
Respondent information								
HH Head: Female (%)	32.24	--	30.30	--	34.52	--	-4.22	0.5427
HH Head Age	38.64	9.70	38.83	9.47	38.43	10.02	0.40	0.7820
HH Head Education above Primary (%)	44.26	--	43.43	--	45.24	--	-1.81	0.8070
Household characteristics								
Number of HH Members	8.42	3.66	8.65	3.86	8.14	3.41	0.50	0.3551
No. of children (<17)	4.60	2.76	4.62	2.58	4.57	2.98	0.05	0.8957
Dependency Ratio	81.22	77.63	80.01	70.26	82.63	85.92	-2.62	0.8209
All of-age children attend school (%)	83.61	--	86.87	--	79.76	--	7.11	0.1956
Economic indicators								
HH owns house (%)	94.51	--	92.86	--	96.42	--	-3.57	0.2919
Electricity (%)	13.11	--	10.10	--	16.67	--	-6.57	0.1898
Number of assets[7]	1.95	1.10	1.89	1.10	2.01	1.11	-0.12	0.4538
All Land Owned (ha)	3.41	3.22	3.26	3.05	3.60	3.42	-0.34	0.4749
Total income (USD)	604.69	1419.0	540.64	1127.3	677.34	1696.47	-136.70	0.5672
No. income sources	1.53	1.05	1.57	1.11	1.49	0.99	0.08	0.6207
Agricultural performance (first/main agricultural season 2021)								
Cultivated land (ha)	4.26	5.37	4.48	6.65	3.99	3.25	0.50	0.5360
No. of crops grown	2.07	0.79	2.02	0.77	2.12	0.80	-0.10	0.3949
Maize produced (kg)	1028.69	1613.2	1183	2068	826.79	616.98	356.30	0.2321
Land with maize (ha)	2.32	2.58	2.37	2.42	2.28	2.66	0.09	0.8308
Maize Yield (kg/ha)	493.59	43.04	501.84	487.93	482.81	453.44	19.02	0.8277
CBO member (%)	61.20	--	65.66	--	55.95	--	9.70	0.1794
Distance to input supplier (minutes)	122.12	122.74	118.99	114.56	125.77	132.49	-6.78	0.7529
Number of Observations	183		99		84			

* p<0.100=10% significant, ** p<0.05=5% significant, *** p<0.01=1% significant.

For categorical variables standard deviations are not reported.

[7] Includes household access to electricity, household owns a mobile phone, household owning a chair (yes/no). The number of assets here is used as an instrument for living standards (Alkire & Foster, 2007)

b. Empirical model

First of all, we estimate the effect of the encouragement package on seed fair attendance based on the following specification:

$$SFA_i = \beta_0 + \beta_1 Treat + \varepsilon_i \qquad (1a)$$

$$SFA_i = \beta_0 + \beta_1 Treat + \gamma X_i + \varepsilon_i \qquad (1b)$$

where the dependent variable in Equation 1a, SFA_i, is a binary variable (0/1) that takes a value of one if farmer i attended the fair, and zero otherwise. $Treat_i$ is another binary variable representing farmers who received the encouragement package, and ε_i is an independent and identically distributed (iid) error term. β_1 is the coefficient of interest as it captures the impact of the encouragement on seed fair attendance. As a robustness check, we re-estimate the equation by adding X_i, a vector of respondent-level controls (see Equation 1b). These latter include household head age, size, the number of assets owned, if the respondent is educated above primary school, and if he/she was the village leader.

To test the impact of the encouragement package on agricultural productivity, we carry out intention-to-treat (ITT) estimations, using both a parsimonious model and one with farmer-level control variables:

$$Y_i = \beta_0 + \beta_1 Treat_i + \varepsilon_i \qquad (2a)$$

$$Y_i = \beta_0 + \beta_1 Treat_i + \gamma X_i + \varepsilon_i \qquad (2b)$$

where Y_i represents the dependent variables of interest: maize yield (in kg of maize produced per hectare) at the endline, or at the end of the first agricultural season in 2023, for farmer i. As some of the farmers that received the encouragement did not attend the seed fair, ITT estimates provide a lower bound effect, depending on the level of non-compliance. We estimate all Equations (1a, 1b, 2a, 2b) by ordinary least squares (OLS). As the allocation of the encouragement packages was random and not assigned at a higher administrative level, we do not cluster our robust standard errors. β_1 is the coefficient of interest as it captures the average difference in outcomes causally attributed to the allocation of encouragement packages.

Finally, we isolate the impact attributable to seed fair attendance, SFA_i. As participation in the fair was voluntary, we use an instrumental variable approach to calculate the local average treatment effect (LATE) (Wooldridge, 2010):

$$SFA_i = \beta_1 Treat + \varepsilon_i \qquad (3a)$$

$$Y_i = \beta_0 + \beta_1 \widehat{SFA_i} + \varepsilon_i \qquad (3b)$$

In the first stage, as shown in equation 3a, random assignment of the encouragement packages, $Treat_i$, serves as an instrument for the endogenous variable, SFA_i. Random assignment of the encouragement packages ensures that the treatment $Treat_i$ passes the exclusion restriction to be used as an instrumental variable. In stage 2, equation 3b, maize productivity, Y_i, is regressed on the predicted seed fair attendance, $\widehat{SFA_i}$. Results of equation 3a show the impact of complying with the encouragement design and actually attending the seed fair. As such, LATE estimates provide an upper bound effect, depending on the level of non-compliance. For both equations, we include first parsimonious specifications and also a specification where controls are added.

c. Results

First of all, our data analysis revealed that 54 percent of the farmers who received the encouragement did actually take it up and attended the seed fair. As the fair was open to the public, approximately 19 percent of control farmers attended as well. Consequently, only 30 percent of treatment farmers and 7 percent of control farmers ended up purchasing maize seeds. These findings further stress that South Sudanese farmers tend to be generally reluctant to participate in seed markets and pay for seeds. Regression results from equations 1a and 1b further stress that farmers who received the encouragement were, on average, 34 percent more likely to attend the seed-fair than otherwise similar farmers (significant at the one percent level; Table 2). The estimated impact of the encouragement on seed fair attendance remains stable after including control variables (Table 2, column 2).

Table 2: The effect of encouragement packages on seed-fair attendance

	(1)			(2)		
Dependent Variable = Seed fair attendance	Coeff.	Std Error		Coeff.	Std Error	
Treatment (Assignment to encouragement)	0.344	0.068	***	0.348	0.068	***
HH head age	--	--		0.002	0.003	
HH size	--	--		0.018	0.008	**
HH head is educated above primary level (0/1)	--	--		0.076	0.073	
HH head sex (1=Female)	--	--		0.120	0.080	
Respondent is village leader (0/1)	--	--		0.089	0.075	
Number of assets	--	--		0.017	0.032	
Constant	0.192	0.04	***	-0.174	0.173	
Number of observations	183			182		
R-squared	0.129			0.178		

* p<0.100=10% significant, ** p<0.05=5% significant, *** p<0.01=1% significant.

In Table 3, ITT estimates (panel A) based on a parsimonious equation (column 1) show that maize yield increased by 347 kg/ha, significant at the one percent level, for farmers who had received encouragement packages. This result remains robust once control variables are included in the ITT analysis (panel A, column 2). These results indicate that the minimum (or lower bound) impact attributable to the provision of encouragement packages – as a proxy for seed market development interventions – is estimated to almost double average maize productivity. Further, Table 3 (panel B) shows that – based on the instrumental variable regression in column 1 – seed fair attendance resulted in an average yield increase of 934 kg/ha, significant at the one percent level. This result also remains stable to the inclusion of control variables, as shown in column 2. These results indicate that the maximum (or upper bound) effect attributable to seed fair attendance – as a proxy for seed market development interventions – is expected to increase maize yield almost threefold.

Table 3: Impact on average maize yield

	(1)			(2)		
Dependent Variable = Maize Yield (kg/ha)	Coeff.	Std Error		Coeff.	Std Error	
Panel A. ITT estimation						
Treatment	347.17	82.84	***	338.67	78.26	***
HH head age	--	--		-2.56	3.30	
HH size	--	--		1.70	9.70	
HH head educated above primary level (0/1)	--	--		370.78	90.49	***
HH head sex (1=Female)	--	--		187.02	97.33	*
Respondent is village leader (0/1)	--	--		70.29	90.82	
Number of assets	--	--		41.16	40.51	
Control group mean (constant)	442.01	42.33	***	213.54	202.41	
Observations	168			167		
Panel B. LATE (IV) estimation: "seed fair attendance" instrumented with "treatment"						
Attended Seed Fair	934.18	278.21	***	892.38	259.45	***
HH head age	--	--		-4.26	4.27	
HH size	--	--		-15.15	13.36	
HH head educated above primary level (0/1)	--	--		292.725	110.03	***
HH head sex (1=Female)	--	--		58.91	120.48	
Respondent is village leader (0/1)	--	--		-43.33	119.89	
Number of assets	--	--		33.66	47.71	
Control group mean (constant)	267.49	96.41	***	388.76	236.61	
Observations	168			167		
R-squared (Panel A)	0.102			0.222		
Underidentification test in LATE (Kleibergen-Paap rk LM statistic)	24.158		***	25.926		***
Cragg-Donald Wald F-Statistic (Weak Identification test), LATE	29.142			30.958		
Stock-Yogo Weak ID (10%), LATE	16.38			16.38		

*: p<0.100=10% significant, **: p<0.05=5% significant, ***: p<0.01=1% significant.

4. Science-Policy Interface

On the 19th of February 2025 KIT and IFDC organized a full-day workshop in Juba, which brought together around 70 representatives from: local seed companies, agro-dealers, farmer and trade associations, the Ministry of Agriculture and Food security – from both federal and state level – donor organizations (permanent representation of the EU as well as the Dutch, Swiss, and Norwegian Embassy), and multiple governmental and non-governmental organizations. The objective of this multi-stakeholder workshop was to develop a Science-Policy Interface (SPI) – as defined by FAO (2024) – to translate our research findings into a broad-based or common seed sector development strategy for South Sudan.

In the first plenary session of the workshop we presented our research findings with the intention to provide a scientific framing for the subsequent policy debate. For the second session we split the participants into break-out groups structured around seven thematic topics, all addressing a key aspect of the national seed system. Each thematic group included different stakeholders in such a way to blend the different interests and competences of participants in discussing potential actions for the development of the national seed system. First, group discussions were aimed at identifying barriers and opportunities, consequently they were steered towards the development of strategic recommendations. At the end of the day each group presented its main strategy in plenary, and each participant was asked to vote for her/his three preferred ones.

a. Discussion

First of all, participants pointed out that South Sudan has been depending on foreign-sourced seed aid for more than 15 years, and that seed aid distribution is crowding out domestic seed producing and trading companies. Yet, free distribution of foreign seeds continues throughout the country, with the exception of Western Equatoria state where the Minister of Agriculture has imposed a ban on foreign seeds importation. Some workshop participants further claimed that even if the imported seeds distributed for free by humanitarian agencies are certified, they may not be seeds at all, but grains that are treated

to look like seeds. Others stressed that humanitarian agencies are largely procuring and distributing second generation hybrid seeds, which are certified and cheap but also extremely low-yielding.

The discussion further revealed widespread confidence in the capacity of domestic and STASS-affiliated seed companies to produce better-quality and higher-yielding seeds, if compared to the free or recycled seeds that are commonly used by South Sudanese farmers. STASS-affiliated companies, however, struggle to find profitable outlets for their seeds, mostly due to the absence of a formal quality control and certification process within the country. This shortcoming is especially affecting the ability of these companies to sell their seeds to institutional buyers, such as humanitarian agencies, hotels, schools and supermarkets. The other option is for these companies to sell their seeds to farmers, mostly through informal and spot markets or agro-dealers (i.e. field-based, itinerant sales agents). However, this marketing strategy appears to be inherently constrained by the presence of high transaction costs and risks. The problem is also that farmers have limited purchasing power and are accustomed to receiving seeds for free.

Overall, the development of a functioning seed-market appear to be hindered by poor governance. Scant financial capacity, constant political instability and widely perceived corruption undermine the ability of the South Sudanese government to make and attract investments in the kind of infrastructures and institutions that are essential for the development of the seed and agricultural market. As a result, trust in the developmental capacity of the government appeared to be generally low among participants.

b. Deliberations

The first deliberations supported by the seed sector stakeholders that took part in the workshop stressed that even if investments are urgently needed to promote and facilitate the development of a national seed-market, these investments should not come at the expense of seed-aid distribution. As such, this deliberation goes against conventional wisdom that financial resources should be progressively shifted away from seed-aid distribution and towards seed-market development. In particular, this deliberation was

justified by the realization that the seed-market is nowhere near to take over seed distribution; and that despite its suboptimal efficiency and effectiveness, seed-aid distribution has an important stabilizing effect in South Sudan.

Therefore, the vast majority of participants supported the idea to focus on investments to promote and facilitate the procurement of local and improved seeds by humanitarian agencies. Local procurement would allow the continuation of distributing seed aid, whilst creating an opportunity for domestic companies to boost seed production without worrying about last mile marketing costs and risks. In this way, seed-aid distribution would also provide access to local and improved seeds to those (many) farmers that are unwilling and/or unable to pay for them. Although local seed procurement by humanitarian agencies has been strongly advocated by STASS and the donor community for quite some time, progress in this direction remains slow.

According to most participants, certified and bulk seed suppliers from Uganda and the rest of the region continue to retain a competitive advantage, vis-a-vis seed-aid agencies. This is mostly due to the absence of a quality control and certification process within South Sudan, and the logistical uncertainties that prevent humanitarian agencies from scheduling seed procurement processes well ahead of time. To address these issues, the South Sudan Seed Hub has been working to bring together the various stakeholders of the national seed sector – including seed companies, research institutes, FAO, and the federal Ministry of Agriculture and Food Security (MAFS) – to develop quality standards and procurement regulations for South Sudan. In parallel, a draft seed sector policy document addressing both seed quality and procurement issues was also developed by MAFS and FAO in August 2024.

Still, participants recognized that the main challenge is given by the limited capacity of the government of South Sudan to finance and lead the establishment of a formal quality control and certification process. Given the importance and urgency of this matter, the majority of workshop participants supported the proposition to establish a private and voluntary quality control and certification body, under the supervision of STASS, the government and other key stakeholders. Based on this deliberation, the establishment of a private and voluntary body,

based on a viable business model (for cost-recovery), could also serve as a stepping stone towards the development of a formal, mandatory and government owned process.

A shift towards local procurement will however and inevitably entail extra logistical costs and risks for humanitarian agencies. For this to happen, the participants asked the government and donor community of South Sudan to stand united and determined in demanding and enabling such a shift. At the same time, workshop participants emphasized that local seed procurement by humanitarian agencies is a short-term solution, and it is important for government and donors to define and pursue also a longer term vision that will finally allow the country to break its dependency on seed-aid and develop a national seed-market. More details on this latter and the other deliberations that emerged from the workshop, as well as on the outcomes of the voting process are presented in Table 4.

Table 4: specific deliberations and voting results

Thematic Group	*Policy Deliberations*	*Voting Results*
Seed breeding	South Sudan needs its own national research organization (NARO) for breeding early generation seeds. Investments in a South Sudanese NARO are essential for the development of the national seed sector. Researchers and breeders should organize themselves into an association, like STASS and develop a seed variety catalog.	4th position
Seed multiplication and seed production	More investments are needed to improve/expand the production, multiplication and quality control of foundation seeds. National seed inspection and certification policy is needed to help the private sector thrive, especially to promote in-country seed production and multiplication.	1st position
Seed marketing	More investments are needed to expand the agro-dealers' network. Agrodelaers networks need to be expanded for farmers to access quality seeds and improve their productivity. Seed marketing strategies should also involve cooperatives, as cooperatives can buy seeds in bulk.	3rd position
Seed demand and use	Government extension services are inadequate, South Sudan relies too much on NGOs for extension purposes, the private sector needs	6th position

	to step in. Village Saving and Loans Associations (VSLAs) can provide the necessary credit for farmers to buy seeds.	
Seed aid	Seed aid needs to be gradually reduced. Everybody is used to seed aid and counting on it, so it cannot be just cut out overnight. To do so, financial resources need to be gradually shifted away from seed aid distribution and towards the development of seed markets.	5th position
Seed quality assurance	In the absence of a seed law and regulation, it is necessary to develop a voluntary quality assurance standard for seed producers, to be developed by all stakeholders, including government and STASS.	2nd position
Seed governance	There is a need to better coordinate seed sector governance between the central/federal ministry of agriculture in Juba and the ministries of agriculture in the different states. A national seed policy is still missing, and should not only be led by FAO and Government, there is a need to involve multiple stakeholders. But policymaking is not enough, the government needs to ensure also the availability of financial resources for policy implementation. The problem is that people are losing faith in government processes.	7th position

5. Conclusions and recommendations

This study provides an analysis of the seed system in South Sudan with the intention to promote and guide its transformation. In doing so, we focus on the identification of existing trade-offs hindering systemic change, and on the creation of new synergies that have the potential to overcome those trade-offs. In particular, we point out that parallel or seemingly unrelated investments in seed-aid distribution and seed-market development lead to an equity-efficiency trade-off. On the one hand, seed-aid distribution efforts appear to ensure basic or universal access to low-yielding seeds, among South Sudanese farmers. On the other hand, seed market development efforts are promoting the production of higher-yielding and better adapted seeds within the country, but they are failing to scale-up seed commercialization and adoption among farming communities. Therefore, we conclude that the transformation of the national seed system requires stronger synergies between international humanitarian agencies and local seed companies.

In more details, we find that South Sudan's agricultural productivity is well below the regional average and constrained by mass distribution of free but imported and low-yielding seeds by humanitarian agencies. As a result, conventional wisdom supports the re-allocation of resources away from seed aid distribution and towards seed market development. However, the active pursuit of such a strategy makes sense only if the market is indeed ready, or mature enough, to ensure access to better adapted and higher-yielding seeds by a critical mass of South Sudanese farmers. We tested the latter assumption against both primary and secondary data, and concluded that the development of domestic seed-markets has indeed the potential to trigger significant productivity gains, but farmers' reluctance to pay for seeds is preventing seed commercialization from reaching a meaningful scale and gaining traction. Finally, we used these findings to facilitate a multi-stakeholder consultation process, which deliberated against the de-funding of seed-aid, considering both the immaturity of the national seed-market and the additional instability and insecurity that ensued the aid-cuts imposed by the U.S. at beginning of 2025. The main deliberation was therefore geared to preserve seed-aid distribution, but make it more impactful. To do so, a strategy to increase the procurement of local and improved seeds by humanitarian agencies was identified as the best option moving forward.

Based on such a strategy, the localization of seed-aid is a necessary stepping stone for South Sudan to advance in its transition towards the establishment of a domestic seed-market. The main problem is that local seed procurement by humanitarian agencies remains largely hindered by the absence of credible and enforceable seed quality standards within South Sudan. In the absence of transparent and legitimate quality control and certification processes, humanitarian agencies will continue to procure certified but low-yielding seeds from abroad, as a way to minimize their potential liabilities. The establishment of a government agency that is dedicated to define and enforce seed quality standards should be considered as a mandatory, albeit long-term plan. In the short run, government and donors could promote, supervise and endorse quality assurance processes that are managed by private or collective organizations. This short-term solution could also generate the necessary know-how in support of the development of a governmental quality assurance

agency. And in the meantime, it could maximize the quality, productivity and revenues of local seed companies, allowing these to leverage seed-aid channels to overcome farmers' reluctance to pay for seeds. In turn, farmers are expected to gain broader access to better-adapted and higher-yielding seeds, and contribute to South Sudan's sustainable agricultural growth and food security.

In more general terms, the main policy recommendation emerging from this study calls for donor countries to stop cutting aid delivery, and try instead to figure out how to make aid more impactful and transformative. The withdrawal of international aid from a country in crisis may be needed to trigger a long-term transition towards market development and economic self-reliance, but it can also exacerbate instability and insecurity over the short-run. Making aid agencies work also for the economic development of a country may be difficult, especially in underdeveloped and conflict-prone countries, where aid delivery per se is already a very complex and risky endeavor. Still, donor countries are unlikely to start re-funding humanitarian agencies unless these become also an efficient and effective means to advance economic development. Much progress could be made in this direction moving forward, as long as humanitarian agencies become more aware, willing and able to progressively localize their aid procurement processes.

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