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# Dynamics of investment in agriculture in Burkina Faso

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## ABSTRACT

Because of rapid urbanisation and increasing food price volatility, Burkina Faso was compelled to prioritise boosting rice production, leading to a ten-year rice development project (NRDS), commencing in 2009. During the project, the country's rice production was 3.2 times higher, on average, than the previous decade, while funding to agriculture increased by 210 per cent. This study concerns the dynamics of funding in influencing rice production according to their sources, by uniquely examining mediation effects through cropland extension, rice yield, worker productivity and land productivity. No significant difference between public and private funding are found. Official development assistance and remittance are fully mediated by cropland extension and worker productivity improvement, while other funds are partially mediated. The NRDS might do well to address the disclosed shortcomings in this study, for example, the stagnation of rice yields may deteriorate the food security of the poor.

## ARTICLE HISTORY

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## KEYWORDS

Burkina Faso; National Rice Development Strategy (NRDS); government expenditure in agriculture; official development assistance; private loan to agriculture; foreign direct investment; remittance; mediation



## SUSTAINABLE DEVELOPMENT GOALS

SDG 2: Zero hunger; SDG 5: Gender equality; SDG 17: Partnerships for the goals

## 1. Introduction

Rapid population growth – at 2.9 per cent annually, between 1980 and 2008 – and urbanisation of over 30 per cent of Burkina Faso's population caused not only food insecurity but also disparities in food consumption. During this period, rice consumption in Burkina Faso increased from 8 kg to 20 kg per capita, forcing a significant increase in rice imports from 1.7 kg to 8.8 kg per capita over the same period (GBF 2021). Severe flooding in 2006, and the subsequent food price crisis in 2007 to 2008, exacerbated the situation, threatening food security and political stability across the region; for example, Burkina Faso declined quickly on the Political Stability and Absence of Violence Index, from 0.31 in 2007 to –0.12 in 2010 (WB 2023).

In response to food-price volatility and other challenges threatening food security, such as population growth, rapid urbanisation, climate change, and natural resource degradation, the Tokyo International Conference on African Development in May 2008 launched the Coalition for Africa Rice Development (CARD), with 23 member states including Burkina Faso. Since its creation, it has supported the efforts of African countries to double the production of rice in Africa a period of over ten years, with the objective of closing the gap between supply and demand and contributing to the achievement of food security and poverty reduction in the continent. The Burkina Faso Government endorsed the National Rice Development Strategy (NRDS-I) in 2008 as an action plan to implement the CARD, coordinating with on-going projects such as the National Program for the Rural Sector. NRDS-I achieved the goal of doubling rice production from 214,000 tonnes in 2009 to 451,000

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tonnes in 2021, with an average growth rate in rice production of 7.6 per cent between 2009 and 2021 (FAO 2023). Contemporaneously, about US\$ 653 million annually, on average, poured into the agriculture sector from various sources – 2.1 times more, on average, than previous annual funding amounts between 1999 and 2008.

However, like other developing countries, Burkina Faso, under constrained financial resources, requires a more effective and efficient allocation of resources. Previous studies paid scant attention to the mechanisms of funding from various sources affecting agricultural production. This study aims to illustrate mediators between funding and rice production using a mediation analysis based on the elastic net regression model, with a balanced assessment of the contribution of funding, both domestic and external, and between public and private sectors, categorised as per Table 1, following FAOSTAT's investment statistics domain.

At certain levels, public investment may be overlaid with other types of investment; government is generally more concerned with enhancing investment in agriculture using supportive policies and budgets. This paper suggests that – for the second round of NRDS from 2021 to 2030, discussed in the Rice for Africa Forum<sup>1</sup> in February 2021 – governments should understand the underlying mechanisms of funds from various sources to find the best mixture of each stakeholder to achieve the target under resource constraints.

## 2. Literature review

Valuable studies on the best strategies for rice development already existed before CARD was initiated. Lançon and Erenstein (2002) weighed up two scenarios: intensified farming to raise productivity and expanding areas of cultivation. They concluded that intensified farming, by using the best varieties and most appropriate technologies, may produce rice more precipitously than through expanding cultivation areas, thus outpacing population growth. Balasubramanian et al. (2007) confirmed that rice is the most appropriate crop in Africa – as it has plenty of available labour, including from women farmers, and wet land, especially in the rainy season – as long as modern inputs and capital are provided to small farmers. They made active government leadership and private–public partnerships a requirement to resolve the constraints of capital. ACET (2023) affirmed this approach, with success stories of government interventions and private–public partnerships to improve agricultural productivity: Ghana's online platforms such as Esoko, Farmerline, and Trotro Tractor, enabling smallholder farmers to gain easier access to critical market insights and extension services; Malawi's land reform program addressing unequal ownership of land; and Senegal's comprehensive land reform program through the Millennium Challenge Corporation.

Ritchie (2022) pointed out variations in channels of cereal production between sub-Saharan Africa and South Asia; between 1980 and 2018, both regions achieved a notable cereal production increase: threefold in sub-Saharan Africa (from 53 to 161 million tonnes), and 230 per cent in South Asia (from 189 to 440 million tonnes). However, sub-Saharan Africa exploited 64 million hectares of cropland over that period, while South Asia achieved its increase without having to exploit further cropland. Consequently, cereal productivity increased just 30 per cent in sub-Saharan Africa, while it grew by 113 per cent in South Asia.

Worker productivity in sub-Saharan Africa, ensuring a growing income, which, in turn, creates consumption power and investment for further productivity, also fell behind that of other

**Table 1.** Investments in agriculture classification.

	Public	Private
Domestic	Government expenditure in agriculture	Private loan to agricultural sector
External	Official development assistance (ODA)	Foreign direct investment (FDI) Remittance

Source: FAO (2023).

regions. The stagnation of agricultural productivity in Burkina Faso was attributed to low worker productivity, which was less than half the global average in 2021, due to the lack of provision of quality technical assistance and training needed for small farmers (Myeki, Bahta, and Matthews 2022; UNCTAD 2022; WB 2020). Nelson and Phelps (1966) urged that the absorptive capacity of host countries determines the spillover effects of new technology and managerial skills that FDI may bring to developing countries.

It is undeniable that implicit and explicit discrimination against women keeps worker productivity from growing in Burkina Faso, despite institutional efforts for mainstreaming gender issues, such as the National Gender Policy in 2009. In 2022, about 71–91 per cent<sup>2</sup> of women do not have a valid national identity card without which they cannot access administrative procedures or financial services (Tanager 2023). Women smallholder farmers in Nigeria, rejected by an agricultural bank, could not obtain a single-digit or farmers' loan, but rather would have to secure a double-digit loan from commercial banks. One interviewee (ActionAid 2019) said that she wanted to spend the money that she would have had to pay in order to open a bank account on food for her children. Another interviewee said herdsmen threatening them with guns took their farm that she managed using the loan. Such unhelpful situations led women farmers to preference or settle for ready cash, albeit by selling rice to local traders at reduced prices, rather than selling at an advantageous price later, thus causing a period of interim debt. The reluctance of women farmers to accept credit due to financial illiteracy, and other barriers in access to credit, led to a decrease in the use of herbicides and fertilisers, making for reduced productivity and income in comparison with male farmers (Moseley and Ouedraogo 2022).

The FAO (2011) reported that many developing countries are experiencing underperformance in agriculture due to prevailing gender-based discrimination in access to essential resources and services. It estimated that, potentially, increases of 20 to 30 per cent in productivity and 2.5 to 4.0 per cent in output would be possible by enabling women farmers' access to resources, on a par with men farmers. AfDB (2021) proposed several recommendations promoting women's financial inclusion, such as guaranteed funding and a tripartite collaboration made up of government, banks, and women's organisations. The importance of efficient and effective funding in agriculture to solve resource constraints in developing countries cannot be emphasised enough as poor performance in agriculture has been closely related to limited access to credit, as well as factors discouraging financial companies from investing in agriculture, viz., market failure, political instability, climate change, and high entry and operational costs in rural areas (FAO 2013; Gayi, Nkurunziza, and Halle 2009; PLGS 2012).

Zidouemba and Gérard (2014) warned of the potential consequences of the degradation of agricultural productivity in Burkina Faso and urged that public investment in agriculture can improve agricultural productivity and eradicate food insecurity within five years, based on several scenarios regarding lack of labour and price volatility. Marcos (2019) demonstrated the positive impacts of public investment on agriculture with the case study of 21 OECD countries over the period from 2000 to 2017, proposing that one per cent of government expenditure brings forth 0.18 per cent of private investment. Alabi and Abu (2023) took the view that only public capital expenditure showed positive effects on agricultural productivity over time in a case study of Nigeria using data from 1981 to 2014. They also proposed that public spending on irrigation especially stimulates greater private investment in agriculture.

Meanwhile, remittance is increasingly highlighted as a stable and unconditional resource for farmers, although the portion of remittance devoted purely to agriculture has a wide estimate range from about 1 per cent to 10–12 per cent (FAO 2013; Gayi, Nkurunziza, and Halle 2009; IFAD 2023). Iheke (2016) emphasised the merit of remittance as offering greater stability than either FDI or ODA in Nigeria, underlining that farmers are able to buy agricultural inputs and lands using remittances and to invest in education over the long term. In Burkina Faso, circa 4 per cent of the population (0.75 million in 2020) migrated as mainly seasonal agricultural workers, and remittance from this workforce reached 3 per cent of the GDP in 2022 (WB 2023). Despite remittance's usefulness, transaction fees have created economic unease in Africa, as an insecure and inaccessible

banking system can charge 20 to 30 per cent more than in other regions (Heitzig 2020; Scharwatt and Williamson 2015; WB 2022).

The efforts of authorities to promote financial inclusion could be hindered by security issues caused by terrorist attacks in remote areas, a rising phenomenon in recent years as the recent Political Stability and Absence of Violence Index showed. The digital banking system is currently identified as an alternative accessible system in rural areas in Africa, as mobile transactions have grown exponentially in West Africa, especially in Nigeria, Ghana, and Senegal, where registered accounts doubled between 2013 and 2023. Low levels of mobile ownership and mobile transaction taxation have impeded the digital banking system from being universally accepted in the region (GSMA 2024; IFAD 2016; World Bank 2018; World 2019).

### 3. Data and methodology

#### 3.1. Data

This paper collects 17 data series from international organisations and official country websites (see the Appendix). There are five aggregate investments in agriculture according to the sources: government expenditure in agriculture, ODA, private loans to agriculture, FDI,<sup>3</sup> and remittance<sup>4</sup> in US\$ million in constant prices. NRDS-I is a dummy variable representing the project period from 2009 to 2021 with a value of 1. There are production quantities of rice (tonnes) for the dependent variable and four mediators: crop area of rice (ha), rice yield (hectogram per hectare [hg/ha]), value added to agriculture per worker as a proxy of worker productivity, and value added to agriculture per unit of land as a proxy of land productivity in US\$ in constant prices.

Last, the following variables affecting rice production were selected and controlled: annual precipitation (millimetres per year), annual temperature (median annual temperature in degrees Celsius), total fertiliser consumption (kilograms per hectare), international rice price (US\$ per metric tonnes) of Thailand 5 per cent broken rice, and the Political Stability and Absence of Violence/Terrorism Index (PSI), given in units of a standard normal distribution (−2.5 to 2.5).

Monthly data are converted into annual values using an arithmetic mean method.

Those few missing values (circa 2 per cent) were imputed by the author using the exponential smoothing (ETS) algorithm and moving average growth rate of GDP and value added to agriculture.

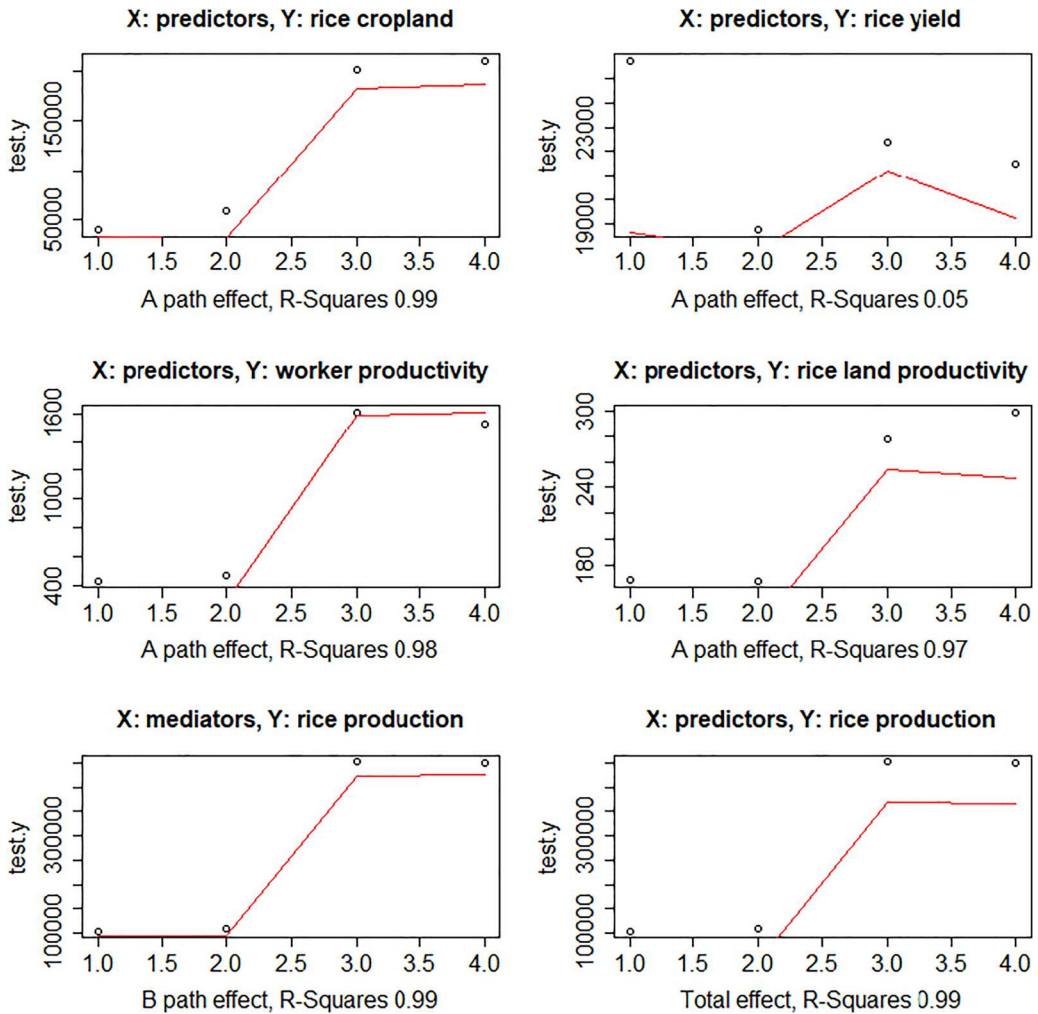
#### 3.2. Methodology

The elastic net regression model of formula (1) minimises both the bias and the variance of the multiple linear regression model by giving penalties between 0 and 1 to minimise the size of all coefficients ( $\alpha = 1$ , approaching to the ridge regression) or to allow some coefficients to be minimised to zero ( $\alpha = 0$ , approaching to the lasso regression), resulting in pulling those variables out from the model.

$$\frac{\sum_{i=1}^n (y_i - x_i^T \hat{\beta})^2}{2n} + \lambda \left( \frac{1 - \alpha}{2} \sum_{j=1}^m \hat{\beta}_j^2 + \alpha \sum_{j=1}^m |\hat{\beta}_j| \right) \quad (1)$$

where  $x_i = (x_{i1}, \dots, x_{im})$ ,  $\hat{\beta} = (\hat{\beta}_1, \dots, \hat{\beta}_m)^T$ .  $\lambda$  is the shrinkage parameter:  $\lambda = 0$  when no shrinkage is performed, and as  $\lambda$  increases, the coefficients are increasingly shrunk. This model is optimised by choosing  $\alpha$  and  $\lambda$  using the “ensr” package of R, resulting in the lowest optimal error for each combination of dependent and predictor variables. The elastic net regression model produces the coefficients of statistically significant variables of close-to-zero  $p$ -values<sup>5</sup> but, unfortunately, it would not produce a  $p$ -value or confidence interval automatically. The model prediction tested for a set of data spared from the dataset for modelling and R-squared values is as per Figure 1.

Furthermore, the mediation analysis is conducted to reveal the paths through which each fund influences rice production. The Sobel test shows that rice yield does not have a mediation effect



**Figure 1.** Plots of observed and predicted values using elastic net regression model and *R*-squared values. Source: Authors calculation based on data from FAO and WB (2023).

between funds and rice production at a significant level, while other mediators associate each fund with rice production significantly at the 0.05 level (Table 2). The total effect (T) is the coefficient of the predictor in the total-model without mediators as shown in Figure 2. The indirect effect through the mediator is the result of  $A \times B$ , where A is the coefficient of the predictor against the mediator and B is the coefficient of the mediator against the dependent variable. The direct effect, C, is the difference of the total effect and the mediation effect ( $T - A*B$ ). If a mediator explains all variation of the dependent variable, it is called full mediation. If it explains only some of the variation, it is called partial mediation.

#### 4. Result and discussion

To date, many African countries have relied on crop land cultivation rather than improving rice yield and this approach is seen in the NRDS-I implementation plan in Burkina Faso (GBF 2011). During the NRDS-I, the country attained production of 336,000 tonnes of rice, on average, increasing 3.2 times from 104,000 tonnes between 1999 and 2008; areas of 155,000 hectares for rice cultivation,

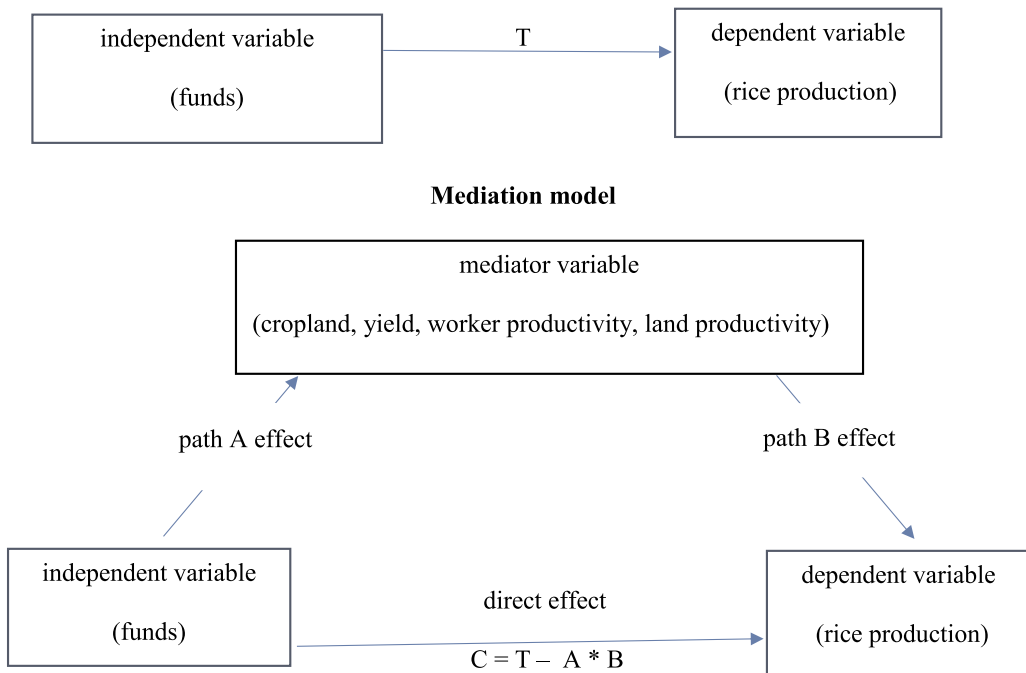
**Table 2.** The Sobel test result on the significance of a mediation effect.

		Rice cropland cultivation	Rice yield	Worker productivity	Land productivity
Government expenditure to agriculture	z.value	7.58	1.62	7.20	5.02
	p.value	0.00	0.11	0.00	0.00
ODA	z.value	10.57	1.57	5.20	1.41
	p.value	0.00	0.12	0.00	0.16
Private loan to agriculture	z.value	3.86	1.57	4.77	3.60
	p.value	0.00	0.12	0.00	0.00
FDI	z.value	3.16	1.65	2.72	2.75
	p.value	0.00	0.10	0.01	0.01
Remittance	z.value	5.40	0.62	5.44	3.08
	p.value	0.00	0.53	0.00	0.00
NRDS-I	z.value	11.26	1.79	7.53	5.56
	p.value	0.00	0.07	0.00	0.00

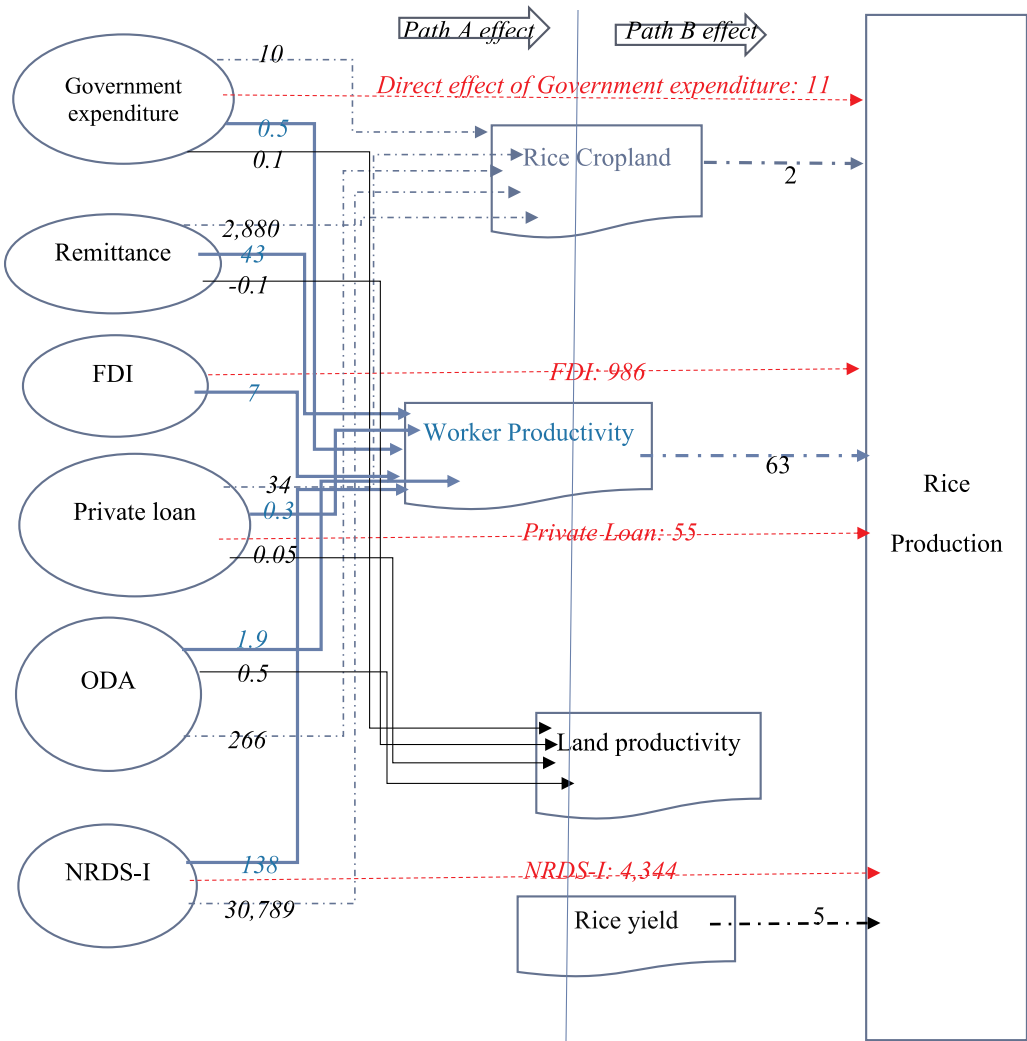
Source: Author's calculation.

increasing 3.1 times from 50,000 hectares; a rice yield of 22,000 hectograms per hectare (hg/ha), marginally increasing from 21,000 hg/ha; agricultural worker productivity of US\$ 1,339 per annum, escalating from US\$ 545 per annum; agricultural land productivity of US\$ 230 per hectare per annum, growing from US \$176 per hectare per annum during the project period; and a total investment of US\$ 653 million, on average, in agriculture, increasing the annual investment between 1999 and 2008 by 2.1 times.

The diagram in Figure 3 shows the influence that flows from funds to rice production via path A (Table 3), path B (Table 4), and direct effect, as per Table 6. The mediation effect of rice crop land cultivation is not significant, despite land for rice crops being the greatest beneficiary of the NRDS-I. Not all the mediators contribute to rice production positively. Land productivity is negatively



**Figure 2.** Diagram of total-effect model and mediation model. Source: Author modified figure from Wikipedia ([https://en.wikipedia.org/wiki/Mediation\\_\(statistics\)#/media/File:Mediation\\_Model.png](https://en.wikipedia.org/wiki/Mediation_(statistics)#/media/File:Mediation_Model.png)).



**Figure 3.** Diagram of direct and indirect influence flows of funds to rice production. Source: Authors calculation based on data from FAO and WB (2023).

**Table 3.** A path effect table expressed as coefficient of predictors against mediators, Burkina Faso, 1980–2021.

	Rice cropland cultivation: A1	Rice yield: A2	Worker productivity: A3	Land productivity: A4
(Intercept)	-235,958	45,225	-2,311	-363
<b>Government expenditure to agriculture</b>	<b>10</b>	<b>4.1</b>	<b>0.5</b>	<b>0.1</b>
<b>ODA</b>	<b>266</b>	<b>3.9</b>	<b>1.9</b>	<b>0.5</b>
<b>Private loan to agriculture</b>	<b>34</b>	<b>3.9</b>	<b>0.3</b>	<b>0.05</b>
<b>FDI</b>	<b>.</b>	<b>39</b>	<b>7</b>	<b>.</b>
<b>Remittance</b>	<b>2880</b>	<b>-268</b>	<b>43</b>	<b>-0.1</b>
<b>NRDS-I</b>	<b>30,789</b>	<b>536</b>	<b>138</b>	<b>.</b>
Fertilizers	979	98	13	2.1
Temperature	7,943	-1,075	74	14
Precipitation	13	4.4	0.3	0.1
Rice price	41	-1.0	.	0.1
Political Stability	-26,287	92	-208	.
R-Squares	0.99	0.06	0.98	0.97

Source: Author's calculations using the elastic net model.



**Table 4.** B path effect table expressed as coefficient of mediators against rice production, Burkina Faso, 1980–2021.

	Path effect B
(Intercept)	–385,371
<b>Rice cropland cultivation: B1</b>	<b>2</b>
<b>Rice yield: B2</b>	<b>5</b>
<b>worker productivity: B3</b>	<b>63</b>
<b>Land productivity: B4</b>	<b>–251</b>
Fertilisers	185
Temperature	9,526
Precipitation	36
Rice price	34
Political Stability	–996
R-squares	0.99

Source: Author's calculations using the elastic net model.

associated with rice production, while worker productivity mediates rice production very effectively. The mediation effect of rice yield is positive but statistically insignificant as per the Sobel test result (Tables 2 and 3). Therefore, the examination of the mediation effect concentrates on two paths: through rice cropland cultivation, and worker productivity improvement.

ODA was used to pursue NRDS-I in the following ways: ODA funding toward crop production projects increased during the NRDS-I project by 1.6 times, on average, compared to the previous decade (1999–2008); the average amount for water and land development projects rose 1.5 times; the average amount for agricultural input, pest control, and plant and post-harvest protection projects rose 2.1 times for the same period. As a result, the total impact of ODA or the coefficient in the total-model was 422 (Figure 2 and Table 5), influencing indirectly through rice cropland cultivation (three quarters) and worker productivity improvement (one quarter) exceeding the total impact, as per Table 6. Therefore, there is a full mediating relationship between ODA and rice production via cropland extension and worker productivity improvement.

Government spending accounted for more than half of the total funding in agriculture for the NRDS-I period; the central government increased funding dedicated to agriculture from 2.13 per cent of its total spending in 2009 to 4.01 per cent in 2021 (FAO 2023). The government supported rice production, through research and extension services, irrigation schemes, and introduction of improved inputs for the NRDS-I (GBF 2011; UNOCHA 2020). As a result, the total contribution of government expenditure to rice production was 60: through worker productivity improvement (33), through crop land extension (16), and, the remainder (11), directly, as per Table 6. In other words, there is a partial mediating relationship between government expenditure in agriculture and rice production.

**Table 5.** Total effect table expressed as coefficient of predictors against rice production, Burkina Faso, 1980–2021.

	Total effect (T)
(Intercept)	–281,560
<b>Government expenditure to agriculture</b>	<b>60</b>
<b>ODA</b>	<b>422</b>
<b>Private loan to agriculture</b>	<b>128</b>
<b>FDI</b>	<b>1,452</b>
<b>Remittance</b>	<b>6,451</b>
<b>NRDS-I</b>	<b>64,619</b>
Fertilisers	3,058
Temperature	7,776
Precipitation	60
Rice price	62
Political Stability	–55,529
R-Squares	0.99

Source: Author's calculations using the elastic net model.

As Iheke (2016) emphasised, the role of remittance in promoting agriculture in Burkina Faso was significant in this study. Remittance made the largest contribution to rice production (6,451), only indirectly, through rice cropland cultivation (two thirds) and worker productivity improvement (one third), revealing a full mediation effect between remittance and rice production, as per Table 6.

The other side of the coin shows that the domestic finance market was unfavourable to farmers (GBF 2011; PLGS 2012; USAID 2021). Private banks mainly focused on cotton cultivation industries which accounted for 14 per cent of total exports and 65 per cent of household income in 2011 (A2F 2015). However, farmers were willing to switch agricultural production from cotton to crop if reliable credit schemes for inputs were available as the margins of raw cotton production were not satisfactory (Dowd-Urbe 2014; Porgo et al. 2018). The government recognised the necessity of promoting private loans in agriculture, so made use of the NRDS-I project to encourage private loans by methods such as guiding micro-finance companies to finance rice production activities, providing guarantees to lending institutions, and renovating the land tenure regulation<sup>6</sup> so that farmers may use this registered tenure as collateral for financial institutions. These steps improved overall private finance performances as follows: commercial bank branches per 100,000 adults increased from 1.83 in 2009 to 2.82 in 2020; account ownership among populations aged 15 and over surged from 15.7 per cent in 2011 to 51.3 per cent for men, 30 per cent less for women in 2017 (WB 2022). Hence, private loans to agriculture increased dramatically from US\$ 50 million in 2011 to US\$ 156 million in 2017, but decreased to US\$ 90 million in 2021 (FAO 2023).

The impact of private agricultural loans for rice production (coefficient in the total-model) totalled 128: 54 directly and 74 indirectly. Private loans promoted rice production indirectly through rice cropland cultivation (56) and worker productivity improvement (17), proving the existence of a partial mediation effect between private loans to agriculture and rice production, as per Table 6.

On the other hand, total FDI inflows to Burkina Faso were 1.4 per cent of GDP, on average, during the NRDS-I period, due to low productivity, except for gold mining and the cotton industry. This is lower than average for sub-Saharan African countries, at 2.3 per cent of the GDP, even though Burkina Faso enjoyed enormous growth in FDI inflows from US\$ 0.4 million in 1990 to US\$ 151 million in 2019, with a peak of US\$ 398 million in 2013 (FAO 2023). FDI experienced a serious setback with COVID-19, resulting in negative inflows in 2020 and 2021. About 45 per cent of FDI inflows between 2010 and 2018 was held by the gold mining and related industries, and 22 per cent by the cotton production and processing industry – others were for construction and other businesses supporting urbanisation (WB 2019). The total influence of FDI on rice production was 1,452 with direct impact (two thirds) and indirect impact (one third) through worker productivity improvement alone, as per Table 6. Hence, there is a partial mediation effect between FDI and rice production through worker productivity improvement.

NRDS-I represents the government's intervention in various forms, including motivation of resources, supportive policies and regulations, and payment guarantees for farmers who do not

**Table 6.** The direct and indirect effects of funds on rice production.

	Total effect (T)	Direct effect (C) T-M	Indirect effect (M) $\sum A_i * B_i$	M-effect through cropland A1*B1	M-effect through rice yield A2*B2	M-effect through worker productivity A2*B3	M-effect through land productivity A4*B4
Government expenditure in agriculture	60	11	49	16		33	
ODA	422	-140	562	446		116	
Private loan for agriculture	128	55	73	56		17	
FDI	1,452	986	466	.		466	
Remittance	6,451	-10	7,550	4,828		2,722	
NRDS-I	64,619	4344	60,275	51,609		8,666	

Source: Author's calculation using the elastic net model.

have enough collateral, described as chronic weak points in Burkina Faso (USAID 2021). The total impact of the NRDS-I on rice production is dominant with 64,610, which indirectly comprises rice cropland expansion (80 per cent) and worker productivity improvement (7 per cent). The direct impact of NRDS-I to rice production is only 13 per cent of the total impact, as per Table 6. This result confirms the efficiency of the NRDS-I project by achieving 3.2 times the rice production, exceeding the target of doubling rice production over ten years. The NRDS-I also achieved the further aim of strengthening human capacity in the rice sector by increasing worker productivity in agriculture by 2.5 times that of the previous decade.

Last, Table 7 highlights the dynamics of investment in agriculture in Burkina Faso once more. Setting aside its own contribution to rice production, ODA caused investment in agriculture from government and remittances – and remittances also caused the government to increase expenditure on agriculture; Zidouemba and Gérard (2014), Marcos (2019), and Alabi and Abu (2023) all noted that public investment encourages private investment in agriculture.

One important observation in this study is that there was little discernible improvement in rice yield, although government spending more than doubled between 2009 and 2021, and FAO (2023) confirmed that about 75 per cent of government expenditure in agriculture was capital spending between 2008 and 2011. This result disagrees with Alabi and Abu's (2023) insistence that public capital expenditure has produced positive effects in agricultural productivity over time, and we may find the answers by taking into account weak worker productivity, institutional issues, and Ebola outbreaks disrupting labour forces (Myeki, Bahta, and Matthews 2022; Nelson and Phelps 1966; UNCTAD 2022; WB 2020). The absorptive capacity of host countries determines not only the spillover effects of new technology, but also the impact of capital inflows, as in the finding of this study: worker productivity mediates funds to rice production most efficiently, as shown in Tables 4 and 6.

It is worth pointing out institutional issues such as political instability, which result in administrative inefficiency, thus hindering public investment for agricultural productivity in Burkina Faso. Owing to its weak predictive power ( $R^2 = 0.05$ ), it is premature to propose any conclusion as yet but the influence of political stability on rice yield is highly positive, as per Table 3. Of course, the impact of political stability on economic development continues to be debatable. For example, Rwanda and Ethiopia showed notable economic growth during the period of political stability through military dictatorship while Eritrea and Gambia did not (Shepherd 2010). Further studies are requested on this

**Table 7.** The result of Granger causality test from variable 1 to variable 2.

Var1	Var2	1 year lag	2 year lag	3 year lag	4 year lag	5 year lag
Government expenditure	ODA	0.97	0.80	0.94	0.81	0.55
Government expenditure	FDI	0.77	0.95	0.97	0.99	0.99
Government expenditure	Private loan	0.14	0.25	0.49	0.66	0.82
Government expenditure	Remittance	0.85	0.83	0.99	0.93	0.93
ODA	FDI	0.82	0.94	0.97	0.74	0.62
ODA	Private loan	0.83	0.94	0.99	0.98	0.99
ODA	Remittance	0.96	0.00**	0.00**	0.57	0.59
FDI	Private loan	0.84	0.94	0.98	0.96	0.95
FDI	Remittance	0.82	0.97	0.99	0.81	0.64
Private loan	Remittance	0.75	0.83	0.27	0.08	0.05*
Var1	Var2	1 year lag	2 year lag	3 year lag	4 year lag	5 year lag
ODA	Government expenditure	0.72	0.61	0.00***	0.00***	0.99
FDI	Government expenditure	0.54	0.81	0.93	0.98	0.97
Private loan	Government expenditure	0.90	0.64	0.91	0.95	0.67
Remittance	Government expenditure	0.01*	0.04*	0.05	0.06	0.64
FDI	ODA	0.83	0.70	0.80	0.88	0.96
Private loan	ODA	0.79	0.98	0.98	0.98	0.99
Remittance	ODA	0.63	0.43	0.88	0.42	0.44
Private loan	FDI	0.81	0.96	0.98	0.99	0.99
Remittance	FDI	0.81	0.93	0.98	0.91	0.63
Remittance	Private loan	0.99	0.84	0.96	0.72	0.33

Source: Author's calculation using R programming.

relationship with broad observations. Private–public partnerships may complement the lesser developed areas of institutions (Balasubramanian et al. 2007; Lançon and Erenstein 2002).

Last, the imbalance between men and women farmers' access to credit may inhibit the adoption of strategies to enhance rice yield in Burkina Faso (Moseley and Ouedraogo 2022; Theriault, Smale, and Haider 2017). For instance, women farmers are particularly vulnerable to climate changes since they do not have the means to invest in adaptation techniques or the appropriate tools; hence, they may experience income decline, negatively affecting the food security and nutrition of their families, as women farmers spend their income primarily on children's food and education. However, a lack of gender-segregated data also hinders this paper from dealing with this interesting facet. Further studies at this level would stimulate data production and disaggregation by gender.

## 5. Conclusions

This study has uniquely illustrated how funding sources have influenced rice production under the framework of the NRDS-I project. This finding provides a broad outline for researchers and policy-makers on the influencing mechanisms of funds on rice production, which may prove helpful in mobilising the most efficient resources for the second round of NRDS, further contributing towards a long-term financial strategy for rice development.

The project was successful in motivating resources and tripling rice production during the target period, mainly through cropland extension and worker productivity improvement. The second round of NRDS might do well to address the disclosed shortcomings in this study, for example, the stagnation of rice yields may deteriorate the food security of the rural and urban poor (Zidouemba and Gérard 2014).

There are four policy suggestions: the promotion of rice yields should be prioritised in the second round of NRDS, with practical efforts such as the establishment of infrastructures and the provision of better inputs and extension services, including legal and institutional affirmative policies; external investors should extend or diversify their interests from the cotton industry to crop production and agriculture value chains, which should lead to job and market creation; global efforts are required to improve the current financial transferring system in a more efficient and economical manner to lower transfer costs to Africa; and particular attention should be paid to facilitating the role of women, to wit: a special fund for women, a guarantee scheme for women's loans, the establishment of women's cooperatives, the effort of various extension services, and more wide-spread and intense education to change attitudes toward credit.

## Notes

1. Rice for Africa forum, "Working Week for the finalization of NRDS II Concept Notes in Burkina Faso", 22–26 February 2021. <https://riceforafrica.net/burkina-faso-february-2021/>
2. data from 400 villages participating in the Soutenir l'Exploitation Familiale pour Lancer l'Elevage des Volailles et Valoriser l'Economie Rurale II (SELEVER II) project
3. Assumed about 22 per cent of FDI was invested in agriculture in Burkina Faso (WB 2019).
4. Assumed about one per cent of remittance was invested in agriculture as of 2014 (WB 2019).
5. The elastic net is intended to prune out the "zero-valued coefficients", such that you should expect all of the selected coefficients to be significantly different from zero, by virtue of being selected: <https://stats.stackexchange.com/posts/440211/edit>.
6. Law No. 034-2009/AN on Rural Land Tenure of 16 June 2009, Decree No. 2010-400/PRES/PM/MAHRH/MRA/MECV/MEF/MATD on procedures for the development and validation of local land charters.

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## Appendix: Data and sources

Data	Periods	Data sources
Rice production (tonne, annual)	1980–2021	FAO <a href="http://www.fao.org/faostat/en/#data">www.fao.org/faostat/en/#data</a>
Rice productivity (100g/hectare, annual)		
Cultivated cropland for rice (hectare, annual)		
Government agriculture expenditure (US\$ million in 2015 price, annual)	1980–2021	The Regional Strategic Analysis and Knowledge Support System (ReSAKSS) / TarkingIndicators <a href="https://www.resakss.org/">https://www.resakss.org/</a>
Agriculture value added per hectare of agricultural land (US\$ in 2015 price)		
Fertiliser consumption (kilograms per hectare of arable land, annual)	1980–2021	World Bank <a href="https://data.worldbank.org/indicator/NV.AGR.EMPL.KD?locations=BF">https://data.worldbank.org/indicator/NV.AGR.EMPL.KD?locations=BF</a>
Agriculture, forestry, and fishing, value added per worker (US\$ in 2015 price, annual)		
Private loan to agriculture (US\$ million in 2015 price, annual)	1980–2021	FAO <a href="http://www.fao.org/faostat/en/#data">www.fao.org/faostat/en/#data</a> UNCTAD <a href="https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx">https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx</a>
Official development assistance (US\$ million in 2015 price, annual)		
Foreign direct investment (US\$ million in 2015 price, annual)		
GDP deflators (Value US\$, 2015 prices)		
GDP (US\$ million in 2015 price, annual)		
Remittance inflows (US\$ million in 2015 price, annual)	1980–2022	KNOMAD <a href="https://www.knomad.org/data/remittances?tid%255B149%255D=149&amp;page=2">https://www.knomad.org/data/remittances?tid%255B149%255D=149&amp;page=2</a> WB <a href="https://data.worldbank.org/indicator/">https://data.worldbank.org/indicator/</a>
Temperature (Centigrade (°C), monthly)	1980–2021	WB <a href="https://climateknowledgeportal.worldbank.org/country/burkina-faso/trends-variability-historical">https://climateknowledgeportal.worldbank.org/country/burkina-faso/trends-variability-historical</a>
Precipitation (mm, monthly)		
Population, life expectancy	1980–2021	WB <a href="https://genderdata.worldbank.org/countries/burkina-faso">https://genderdata.worldbank.org/countries/burkina-faso</a>
GDP per capita (US\$ in 2015 price, annual)	1980–2021	FAO <a href="http://www.fao.org/faostat/en/#data">www.fao.org/faostat/en/#data</a>
Agriculture, value added (US\$ million in 2015 price, annual)		
Rice price (US\$ per metric tonne, monthly)	1980–2021	Mongabay.com <a href="https://data.mongabay.com/commodities/price-charts/price-of-rice.html">https://data.mongabay.com/commodities/price-charts/price-of-rice.html</a> Index Mundi <a href="https://www.indexmundi.com/">https://www.indexmundi.com/</a>
Rice (Thailand), 5% broken, white rice (WR), milled, indicative price based on weekly surveys of export transactions, government standard, f.o.b. Bangkok		