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Article

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Research in Globalization

Provided in Cooperation with:

Elsevier

Suggested Citation: Amoaning, Felix; Obeng, Camara Kwasi; Cantah, William Godfred (2024) : Impact of natural resource rents on well-being in sub-Saharan Africa: The role of human capital, Research in Globalization, ISSN 2590-051X, Elsevier, Amsterdam, Vol. 8, pp. 1-16, <https://doi.org/10.1016/j.resglo.2024.100203>

This Version is available at:

<https://hdl.handle.net/10419/331129>

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Impact of natural resource rents on well-being in sub-Saharan Africa: The role of human capital

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ARTICLE INFO

Keywords:

Human capital
Natural resource
System GMM and welfare

ABSTRACT

This study contributes to the resource curse literature in diverse means. First, using a non-monetary welfare measure, the study investigates the validity of the resource curse hypothesis in sub-Saharan Africa (SSA). Secondly, the paper examines the impact of natural resource rents on human welfare through the human capital channel and finally investigates the minimum human capital score to avert the resource curse in SSA. The empirical analysis conducted using the system Generalized Method of Moment (GMM) econometric approach on a panel of 32 SSA countries spanning the period 2004–2019, demonstrates that resource rents have a dumping effect on human progress. However, investing in human capital may avert the negative repercussions emanating from the natural resource-welfare link. Further, the study revealed the minimum threshold level for human capital score and tertiary school enrollment rate as 2.40 units and 23.21 %, respectively, necessary to avert the prosperity curse. To increase human prosperity, policymakers are recommended to increase investment in education in order to increase tertiary school enrollment above the estimated threshold and institute policies that will increase the average years the productive unit spent in schooling.

Introduction

Before the pronouncement of the “Dutch disease” and “resource curse”, classical economists including Adam Smith and David Ricardo historically held the perception that countries endowed with natural resources are more inclined to experience swift economic growth (Smith, 1776; Rahim et al., 2021), and all things being equal, could improve their socio-economic welfare relative to countries less endowed with natural resource wealth. In contrast to this preconceived assertion, some recent studies raised criticisms of this ideology (Okyerere et al., 2021; Asumadu et al., 2021). Such studies are aligned with Auty and Warhurst’s (1993) concept of the “natural resource curse” phenomenon, indicating that an exclusive focus on natural resources may have detrimental welfare effects. Such studies suggest that countries focusing on building a resilient economy by strengthening the general welfare of the citizens are more likely to witness sustained rapid economic growth (Adeleye et al., 2020; Menyelim et al., 2021).

Boosting human welfare enhances human economic capacity to live creative, fulfilling, and healthy lives (Western & Tomaszewski, 2016), which improves individuals’ material living benefits and better their health and education status as well as their self-esteem (Stiglitz et al.,

2009). This improvement in human welfare may be influenced by the environment (Subramaniam & Masron, 2020; Khan et al., 2022), as a healthy and sustainable environment is essential for human long-term prosperity. This is because the environment possesses the economic wealth that humans need to survive and thrive (Van Den Berg, 2017). However, excessive reliance on natural resources, which is a component of the environment, for human welfare enhancement could have adverse repercussions on the assimilation function of the environment (World Health Organization (WHO), 2018; Asongu & Odhiambo, 2020; Khan et al., 2022), which could further hinder human prosperity.

Auspiciously, Africa being endowed with abundant natural resources, presents an interesting context. For instance, the continent holds about 8 % of the world’s oil reserves, with natural gas amounting to over 7 % (African Natural Resources Center (ANRC), 2016). Again, it has the world’s biggest reserves of precious metals and homes about 30 % of the world’s mineral reserves (Mulwa & Mariara, 2016; United Nations Environmental Program (UNEP), 2021). Additionally, about 20 % of the global volume of gold production comes from Africa (Gajigo et al., 2012), with about 34 African countries actively involved in gold production (U.S. Geological Survey, 2011). Despite this natural wealth, the rents accrued through extractive and consumptive activities

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<https://doi.org/10.1016/j.resglo.2024.100203>

Received 22 December 2023; Received in revised form 12 February 2024; Accepted 13 February 2024

Available online 22 February 2024

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contribute minimal towards human progress, particularly in sub-Saharan Africa (SSA) (World Bank, 2018a,b). Moreover, several SSA countries, including major oil-producing nations struggle with mismanagement, rent-seeking, foreign ownership of mining companies and at times conflict, impeding economic development and exacerbating poverty and inequality. These challenges raised doubts about the attainability of sustainable development goals (SDGs) in the region and equally justified why most SSA countries are victims of this natural resource curse syndrome (Asiamah et al., 2022).

As a matter of fact, improving human well-being is a major concern for sub-Saharan Africans, which has enthused researchers to highlight the importance of natural resource exploitation and value addition on human well-being enhancement (Pérez & Claveria, 2020; Asumadu et al., 2021; Ofori & Grechyna, 2021). However, the debate on whether natural resource gains spur well-being is inconclusive. Some studies show a negative and significant link between natural resource rents and economic growth (Pérez & Claveria, 2020), while others like Ramli and Safitri (2022) and Katoka and Dostal (2022) refuted the resource curse claims. This debate keeps raging and authors who contributed to the argument used domestic income as the primary welfare measure. The question remains whether an increase in national income “trickles down” to better citizenries’ lifestyles. The use of the gross domestic product alone may be a flawed measure of economic welfare (Lee & Gueye, 2023). This is because GDP is just one of the components of welfare measures and does not take into account a wide range of factors that can affect the quality of life of individuals, such as income inequality, access to education, healthcare, and social cohesion (Coyle, 2014).

Further, current literature that focused on multidimensional welfare such as Lee and Gueye (2023) concentrated solely on the direct impact, without considering various transmission channels such as human capital, financial development, or institutions. This measurement issue and the omission of these contextual factors in previous literature may contribute to the inconclusiveness. The mere existence of natural resources may not foster socio-economic transformation. Fostering socio-economic transformation involves strengthening the productive sectors, either the manufacturing, extraction or agricultural sectors and that largely depends on human capital. Researchers including Eslamloueyan and Jafari (2021) have demonstrated that welfare enhancement through natural resource benefits or exploits is determined by the economy’s human capital development.

As illustrated in Appendix 1, human capital is positively related to human development in SSA. Figs. 1 and 2 further emphasize that SSA countries such as Mauritius, South Africa and Botswana which exhibit superior average human capital and tertiary education enrollment rates (alternative measure of human capital), demonstrate an elevated human welfare (Refer to Appendix 1). Human skills and knowledge increase productivity and efficiency of resource extraction process, usage of resource rents and also help to diversify the economy and reduce over-

reliance on the resource sector. Botswana and South Africa serve as a compelling example, as these countries have successfully overcome the resource curse. This remarkable welfare achievement is attributed to the countries’ huge investment in education as demonstrated by the World Bank data.

Based on the identified gaps, we contribute to the literature by not just investigating the direct impact of natural resource gains on human welfare but to scrutinize the role of human capital in offsetting the negative effect of natural resources on welfare. Thirdly, we estimate the minimum human capital threshold that can avert the negative impact natural resource dependence exerts on human prosperity. We investigate the stated objectives considering data pooled from 32 SSA countries (see Appendix 2 for the list of countries).

The remainder of the paper is structured as follows. In Section ‘Insights from literature’, we briefly discuss theoretical and empirical studies on the natural resource and welfare relationship, whilst Section ‘Methodology’ presents the methodological strategies adopted in this study. Findings and results on the estimated parameters are discussed in Section ‘Descriptive statistics and discussion of estimated results’. In the final section, we conclude and recommend policies based on the findings of the study.

Insights from literature

In this section, we review theoretical concerns and empirical studies underpinning natural resources and socio-economic prosperity.

Theoretical underpinning

The most theoretical studies on natural resources and economic progress are the Dutch disease and the resource curse hypothesis. The Dutch disease paradox originated from the Dutch economic crisis in the 1960s and came into the spotlight, following the discovery of the North Sea oil (Brinčíková, 2016). The concept explains how a sectoral boom results in an adverse general equilibrium effect on the manufacturing sectors or the economy in general. A resource boom as a result of the discovery of tradable natural resources, for instance, gas or a rise in the price of primary resources, may cause countries with comparative advantages in those resources, to increase production. This probably soars exports leading to a real appreciation of the country’s exchange rate and wage upsurge, resulting in labour force mobility to the resource sectors. The appreciation in the domestic currency causes a decline in the country’s international competitiveness of other tradable sectors since the natural resource-based exports crowd out commodity exports (Krugman, 1987), which threatens the country’s risk of de-industrialization.

The core Dutch disease model explains the resource movement and the spending effects as the two key channels through which resource booms may influence an economy negatively. Corden and Neary (1982)

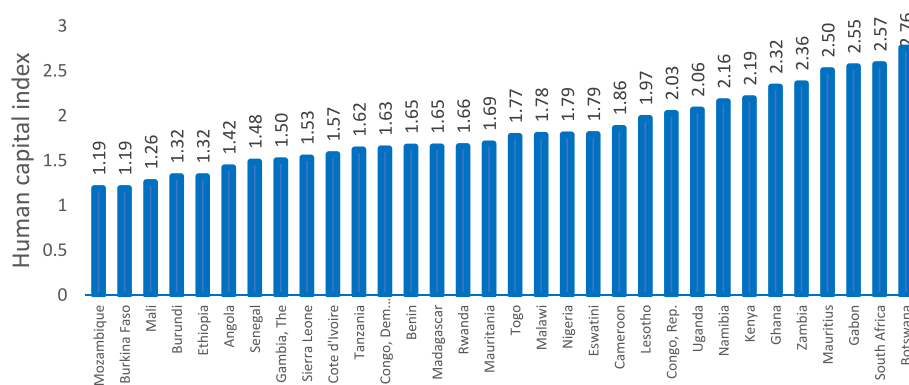


Fig. 1. Human capital index, based on years of schooling and return to education.

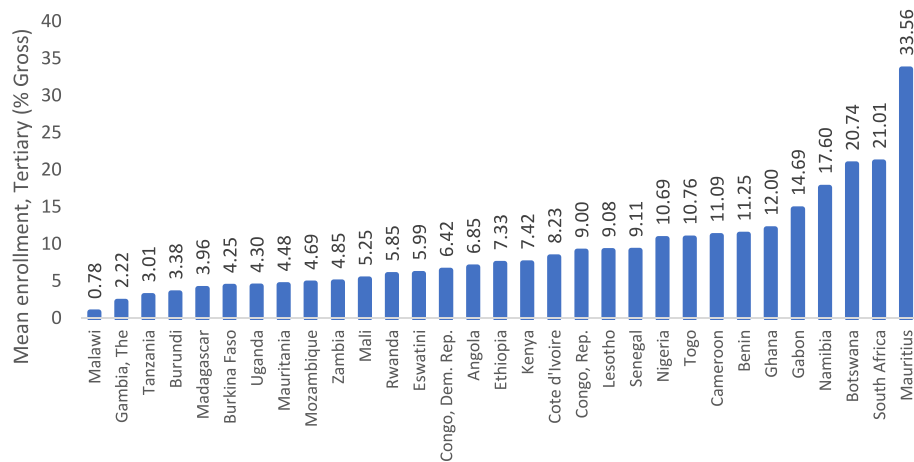


Fig. 2. Human capital measured by school enrollment, tertiary in SSA countries (2004–2019).

framework is based on a three-sector economy; the non-tradable sector, the manufacturing sector and the resource sector. With the resource movement effect, an increase in the price of the natural asset raises the value of labour, causes the marginal productivity of labour to surge, and perhaps increases the wage rate in the resource sector. This inspires labour movement and relocation from the non-tradable and manufacturing sectors to the resource sector. Regarding the spending channel, revenues increase as a result of discoveries of new natural resources or surges in market prices of natural resources, increases domestic spending and imports for both tradable and non-tradable. The spending process increases the exchange rate and forces capital and labour out of the manufacturing sector. As natural resource begins to deplete or the market price declines, the shift from the manufacturing sector becomes disadvantageous. A long period of neglect in the manufacturing sector makes the sector inactive and less able to compete internationally. Hence, the manufacturing sector is unable to replace the resource sector in leading the economy.

Review of empirical studies

Impact of natural resources on human welfare and economic growth

A study conducted by [Okyere et al. \(2021\)](#) on Ghana's economy, placed divergent attention on income gains and health costs related to natural resource exploitation. The mining industry was found to contribute significantly to export earnings and GDP expansions. However, the health cost related to mining activities outweighs the income benefits and causes a decline in labour output and GDP in general. Further, mercury discharge during mining pollutes water bodies, destroys forest reserves and farmlands. [Asumadu et al. \(2021\)](#) extended the scope to include experiences from other SSA countries like Nigeria, Gabon, and Angola. According to [Asumadu et al. \(2021\)](#), the dwindling performance in the agricultural sector after the oil and gas discovery may be a reflection of "Dutch disease". The taking over of community farmlands situated close to oil fields contributes to the drastic fall in food production, surging long-run food inflation. Further, the euphoria and remuneration associated with oil discovery and production result in structural changes. The huge wages in the mining industries cause population drifts from rural agriculture areas to the industrialized urban centres without adequate service and industry job openings to exacerbate the natural resource curse parody.

Similarly, [Pérez and Claveria \(2020\)](#) concentrated on mineral-dependent African economies and reported a weak inverse relationship between mineral dependence and human development, suggesting that upsurges realized from natural resource rents do not materialize in higher economic well-being. The obstruction in economic development in such countries, according to [Pérez and Claveria \(2020\)](#), is due to a

high corruption rate and ineffective governance. These proclamations confirmed [Abdulahi et al.'s \(2019\)](#) earlier study. The threshold model technique employed by [Abdulahi et al. \(2019\)](#) suggested that countries with institutional quality exceeding -1.37 are probable to avert the resource curse. Again, [Ofori and Grechyna \(2021\)](#) diverted from the composite assessment of natural resource gains to individual natural resource rents on economic growth for 43 SSA countries. Both oil and gas rents were revealed to harm economic growth, whilst, forest rents had a direct significant impact on economic growth.

Additionally, [Sinha and Sengupta \(2019\)](#) dealt deeply with human development affairs in 30 Asian-Pacific countries, considering a non-monetary welfare measure. The bootstrapped quantile regression demonstrates that rents received from natural resources negatively impact human development (HDI). However, the individual assessment of coal, minerals, gas, forest and oil rents on human welfare was positive. Recently, [Noumba et al. \(2022a,b\)](#) GMM estimation on 49 SSA countries, equally reported a resource-human development curse evidence. The researchers after disaggregating the natural wealth into individual commodities, concluded that rents accrued from oil, natural gas, minerals and forests do not contribute towards human development in SSA. Likewise, the IV Tobit model employed by [Nchofoung et al. \(2021\)](#) to investigate natural resource influence on inclusive human development (HDI adjusted for inequality), reviewed that surges in resource rents impede human progress in Africa and low-income economies. However, the presence of quality governance could have a positive synergistic effect in mitigating the "resource curse". This resource curse concept was further supported by [Elmassah and Hassanein's \(2022\)](#) study. The authors highlighted that promoting a quality environment is the most influential mechanism in avoiding the curse since the human capital and institutional channels were proven not significant in averting the curse.

On the contrary, other recent empirical studies reported conflicting findings. For instance, the random coefficient model adopted by [Katoka and Dostal \(2022\)](#) on 45 SSA countries demonstrated that natural resource windfall gains undoubtedly contribute to higher economic growth, particularly in economies rich in oil. Similarly, [Lee and Gueye \(2023\)](#) after computing a multidimensional welfare indicator, encompassing income, inequality, and life expectancy, equally revealed resource windfalls to be welfare-enhancing in SSA, although the magnitude of the effect was minimal and statistically not significant, especially in fragile SSA countries. Again, [Dialga and Ouoba \(2022\)](#) adopted Driscoll and Kray estimation techniques and found a positive but minimal impact of extractive resources on overall human development. Their estimation further revealed that an upsurge in resource wealth is detrimental to both education and health dimensions of human well-being. In a departure from the broader assessment of natural resource wealth's impact on aggregate human welfare, [Gani \(2023\)](#)

focused on specific aspects of human well-being, specifically under-five mortality. The multifactor health production model employed in Gani's study demonstrated that gains in natural resource wealth do not reduce under-five mortality rates.

Furthermore, Ramli and Safitri (2022) conducted a comprehensive study by exploring the pass-through effect of natural resource wealth on human welfare, considering capital expenditure as an intervening variable. The study revealed that although total rents derived from natural resources accelerate human development, gains from some individual commodities may have varying effects on human welfare. This assertion from Ramli and Safitri (2022) was further supported by Chen et al. (2023). According to Chen et al. (2023), coal rents align with the neutral hypothesis while rents from oil and gas act as catalysts for advancing human welfare. Additionally, the earlier comparative study of Hota and Behera (2019) on non-mining and mining districts in Odisha state, testified that mining districts in Odisha perform better in uplifting human development and alleviating poverty compared to the non-mining districts.

As the literature review shows, a limited number of studies investigate natural resource wealth on multidimensional welfare in SSA. Furthermore, there is a noticeable gap in the literature addressing the potential mitigating role of human capital in counteracting the adverse effects of natural resource dependence on human welfare. Finally, there is a notable absence of research identifying a threshold level of human capital above which a resource curse transforms into a blessing in SSA.

Human capital and economic growth

Training and education impart useful knowledge and skills that increase workers' productivity and also raise future income streams through lifetime earnings (Becker, 1994). The knowledge stock and the characteristics of workers' either innate or acquired, are productively usable and define human capital. Human capital depreciates due to new knowledge and technologies and the forgetfulness of acquired knowledge. Constant investment is recommended to maximize the benefits to the economy. Scholars have used conventional methods as a proxy for human capital stock. The measurements are characterized by output (e.g., school enrolment rates, scholastic attainments, adult literacy, and average years of schooling), cost (e.g., costs of acquiring knowledge), and income (e.g., benefits obtained from the investment in education and training) methods. Empirical evidence about the three methods has established the relevance of a knowledge-based economy.

Noumba and Feunke (2020) acknowledged the contribution of human capital toward development. Their study revealed that education has a positive effect on health attributes and household well-being. Karakara and Osabuohien (2021) studied inclusive growth in 10 SSA countries and made conclusions cum recommendations that Human development is a sine qua non to achieving inclusive growth and that countries should ensure that their citizens have equitable access to education, basic social services, strong social safety nets, social protection and basic access to healthcare, to achieve growth. Erum and Hussain (2019) investigated the human capital role in the natural resource-welfare relationship. After categorizing their sample into low and high Information Communication Technologies (ICT) diffusion economies, the cross-sectional autoregressive distributed lags estimation outputs affirmed evidence of the resources curse hypothesis only in lower ICT diffusion economies. Further, Rahim et al. (2021) analyzed human development impact through natural resource utilization for eleven countries. Although the results authenticated the resource curse argument, human capital and natural resources were found to jointly exert positive influences on economic outcomes.

Nathaniel et al. (2020) and Oluwatobi et al. (2020) equally made a similar realization. They argued that investing in human capital encourages sustainable growth by lessening the effect innovation has on economic growth in SSA. Again, Asongu and Odhiambo (2020) however proclaimed that economic expansions will inculcate lesser

environmental destruction when human capital is high. According to the authors, enhancing a sustainable environment is a potency of strengthening productivity in the long run. A similar observation was deduced by Erdogan et al. (2021), where human capital advancement was found as a major transmission mechanism to drive a cleaner and sustainable environment. Education encourages cleaner practices that will probably reverse any negative externalities globalization may possess on the environment.

The narratives so far authenticate the inconclusiveness in the resource curse literature and validate the degree to which human capital development is vital in explaining socio-economic development. Human capital can be harnessed for inclusive development and structural diversification. Improvement in socio-economic well-being within SSA may depend on a plethora of interactions and features that relate to human capital.

Methodology

Data and model specification

Data sources

The study utilized a panel dataset from 32 selected SSA countries, with an annual dataset spanning from 2004 to 2019. The choice of the study period and countries are due to data availability and the homogeneity that exists among the countries' cultural, political, social and economic spheres. Human Development Index (HDI) and poverty (povati190) are respectively considered as dependent variables. The main independent variables are total natural resources rents as a share of GDP (natres) and human capital variables, measured by the human capital index (humcap) and tertiary school enrollment (% gross). Six variables in line with econometric prudence are controlled for. For instance, we control for infrastructure index (infrac), gross capital formation as a share of GDP (phycap), trade openness (trade), total unemployment as a percentage of the total labour force (unemploy), financial development index (findevt), and democracy (proxied by Press Freedom Index). The variable names, descriptions and sources are presented in Table 1.

Model specification

Human capital, natural resources and physical inputs contribute to growth (Solow, 1956; Mankiw et al., 1992). To investigate the link between natural resources and human capital on welfare, the theoretical

Table 1
Variables, descriptions and sources.

Variables	Description	Sources
HDI	A composite measure that takes into account three dimensions of human development: healthcare, education and standard of living. (ranges from 0 to 1)	United Nations Development Programme (UNDP)
povati190	Poverty gap at \$1.90 a day adjusted for inflation	Human Progress Data Center
natres	Total natural resources rents (% of GDP)	World Bank
humcap	Human capital index	Penn World Table
sch	Tertiary school enrollment (percentage gross)	World Bank
trade	Trade as a percentage of GDP	World Bank
unemploy	Total unemployment as a percentage of the total labour force	World Bank
infrac	Africa Infrastructure Development Index	African Development Bank.
findevt	Financial development index	International Monetary Fund (IMF)
democracy	Press Freedom Index	Reporters Without Borders
phycap	Gross capital formation as a share of GDP	World Bank

Source: Authors' compilations.

framework adopted is the augmented version of Solow’s (1956) growth model developed by Mankiw et al. (1992). The model explains the differences in economic performances between countries through a production function with constant returns to scale. This is represented in Eq. (1):

$$Y(t) = K(t)^\alpha (A(t) \cdot L(t)^{1-\alpha}) \tag{1}$$

Y denotes the output level, whilst K and L are the capital accumulation and labour, respectively. A is the effectiveness of labour or technological progress and t is the time period. The basic assumption from the model is that human capital contributes to economic growth the same as physical capital. Because the model fails to account for the contribution of natural resources and environment, we extend the model by incorporating natural resources (N), which is assumed to depend on knowledge level (B), into Eq. (1). The production function is rewritten as:

$$Y(t) = K(t)^\alpha \{B(t)N(t)\}^\beta [A(t)L(t)]^{1-\alpha-\beta} \tag{2}$$

We normalize the specified function in Eq. (2), by taking the natural logarithms of both sides of the equation and proceed to find the derivatives of the resulting equation with respect to time (t), to obtain the growth rate. The resulting equation is presented below:

$$g_Y(t) = \alpha g_K(t) + (\beta) [g_B(t)] + \beta g_N(t) + (1 - \alpha - \beta) [g_A(t) + g_L(t)] \tag{3}$$

It is inferred from Eq. (3) that growth rate is a function of physical capital, natural resources, human capital, or labour and technology. Replacing the income growth with the human development index (HDI), which captures the overall multidimensional human welfare measure (i.e., it encompasses income growth, health care and educational dimensions), Eq. (3) is re-written as:

$$HDI_{it} = \theta_0 + \theta_1 physcap_{it} + \theta_2 natres_{it} + \theta_3 humcap_{it} + \theta_4 tech_{it} \quad \text{for } t = 1, 2, 3, \dots, T \quad \text{and } i = 1, 2, \dots, N \tag{4}$$

Based on previous literature and frameworks, labour-augmenting technology (A) determinants like financial development, openness, domestic infrastructure, unemployment rate and democracy enter the model as controls. The baseline model is then specified in Eqs. (5) and (6):

$$HDI_{it} = \theta_0 + \theta_1 natres_{it} + \theta_2 trade_{it} + \theta_3 unemploy_{it} + \theta_4 infrast_{it} + \theta_5 findevt_{it} + \theta_6 democracy_{it} + \theta_7 physcap_{it} + \theta_8 humcap_{it} + \mu_i + \epsilon_{it} \tag{5}$$

$$HDI_{it} = \theta_0 + \theta_1 natres_{it} + \theta_2 trade_{it} + \theta_3 unemploy_{it} + \theta_4 infrast_{it} + \theta_5 findevt_{it} + \theta_6 democracy_{it} + \theta_7 physcap_{it} + \theta_8 sch_{it} + \mu_i + \epsilon_{it} \tag{6}$$

The human capital variables separately enter Eqs. (5) and (6), to avoid multicollinearity. In Eqs. (7) and (8), an interaction between total natural resource rents and the human capital variables are included to ascertain the joint impacts of these variables on well-being.

$$HDI_{it} = \theta_0 + \theta_1 natres_{it} + \theta_2 trade_{it} + \theta_3 unemploy_{it} + \theta_4 infrast_{it} + \theta_5 findevt_{it} + \theta_6 democracy_{it} + \theta_7 physcap_{it} + \theta_8 (natres_{it} \times humcap_{it}) + \theta_9 humcap_{it} + \mu_i + \epsilon_{it} \tag{7}$$

$$HDI_{it} = \theta_0 + \theta_1 natres_{it} + \theta_2 trade_{it} + \theta_3 unemploy_{it} + \theta_4 infrast_{it} + \theta_5 findevt_{it} + \theta_6 democracy_{it} + \theta_7 physcap_{it} + \theta_8 (natres_{it} \times sch_{it}) + \theta_9 sch_{it} + \mu_i + \epsilon_{it} \tag{8}$$

The dependent variable is observed to be dynamic because the variable is expected to depend on its realization. A dynamic panel model,

Table 2
Descriptive statistics of the variables employed.

Variables	Mean	Std. Dev.	Minimum	Maximum
<i>Dependent variables</i>				
HDI	0.510	0.093	0.320	0.804
povatl190	41.453	21.688	0.143	94.300
<i>Interest variables</i>				
natres	11.066	10.727	0.001	58.650
humcap	1.817	0.436	1.107	2.938
sch	8.686	7.218	0.494	44.392
<i>Controls</i>				
trade	70.681	28.523	20.723	161.894
unemploy	8.459	7.670	0.600	31.770
infrast	18.066	13.700	0.649	79.635
findevt	0.163	0.135	0.001	0.646
democracy	29.784	12.635	5.500	81.000
physcap	22.845	8.634	8.951	79.462

Source: Constructed by the authors (2023).

Generalized Method of Moment (GMM) in this case is used in estimating the parameters. For simplicity, we specified the linear model dynamically as:

$$HDI_{it} = \theta_0 + \theta_1 HDI_{i,t-1} + \theta_2 Z_{it} + \theta_3 X_{it} + u_{it} \tag{9}$$

where ($u_{it} = \mu_i + \epsilon_{it}$) is the error term, i is the cross sections in the dataset and t is the time period. From Eq. (9), HDI_{it} is the multidimensional measure of welfare, HDI_{i,t-1} is the lagged value. Z_{it} is a matrix of the components of human capital index (humcap), tertiary school enrollment (sch), and natural resource rents (natres). X_{it} is a matrix that captures the control variables such as unemployment (unemploy), press freedom which is the proxy for democracy, trade as a share of GDP (trade), infrastructure index (infrast), financial sector development index (findevt), and gross capital formation as a percentage of GDP (physcap). However, just like Amoaning and Ahiakpor (2022), the interpretation of the net effects from the interactions of natural resource revenue and human capital in Eqs. (7) and (8) is computed and the resultant equations are expressed respectively as:

$$\frac{\partial hdi_{it}}{\partial natres_{it}} = \theta_1 + \theta_8 \widehat{humcap}_{it}, \widehat{humcap}_{it} \geq 0 \tag{10}$$

$$\frac{\partial hdi_{it}}{\partial natres_{it}} = \theta_1 + \theta_8 \widehat{sch}_{it}, \widehat{sch}_{it} \geq 0 \tag{11}$$

where \widehat{humcap}_{it} and \widehat{sch}_{it} are the average human capital index and tertiary school enrollment rate. The models specified are estimated based on the generalized methods of moment techniques. The GMM controls for endogeneity which is a conspicuous empirical problem in Eq. (9) because the lagged dependent variable is expected to be correlated with the error term. Moreover, the cross-sections exceed the time period, hence the GMM estimator is appropriate to adopt. The empirical rigour of the study begins by estimating the linear model in Eq. (5) using the system GMM proposed by Arellano and Bover (1995); and Blundell and Bond (1998). The two-step system GMM is specifically adapted for this study since the technique is more robust to autocorrelation and heteroscedasticity and also more efficient compared to the one-step (Roodman, 2009). We further tested the robustness of our findings using poverty rate as an alternative welfare measure.

Descriptive statistics and discussion of estimated results

Descriptive statistics

To have a concise overview of the characteristics of the data employed, we briefly looked at the summary statistics for the variables.

As displayed in Table 2, the average human development index (HDI) and poverty rate (povati190) are approximately 0.51 units and 41.45 %, respectively. Based on the United Nations Development programme (UNDP) HDI ranking, the average reported HDI value depicts that sub-Saharan Africa falls within the lower human development classification. Again, the average poverty rate illustrates that about 41.45 % of the population in the sample are below the US\$1.90 poverty line, given the duration of the study. Further, the data reveal that the mean values for total natural resource rents, human capital index and tertiary school enrollment rate are 11.066 % to GDP, 1.817 units, and 8.686 %, respectively.

Discussion of estimated results

To proceed to the estimated models, we examine the smoothness of the variables by adopting the panel stationarity test proposed by Hadri (2000). From Appendix 4, the null hypothesis of stationarity failed to be rejected for all variables, indicating that all variables employed are integrated at levels, hence performing a cointegration test is unnecessary. Moreover, in order not to undermine the statistical significance of our independent variables, we proceed to examine how our regressors correlate with one another. From Table 3, the Variance Inflation Factor (VIF) values are less than 10, and the reported mean VIFs of 2.04 and 1.99 for models 1 and 2, are lesser than the 2.78 thresholds. Further, the correlation matrix presented in Appendix 3 confirms that the predictors do not demonstrate evidence of perfect collinearity.

To examine the objectives, we estimated linear and non-linear dynamic models using the system GMM estimation technique and the estimated outputs reported in Table 4. The linear models in Eqs. (5) and (6) are reported in models 1 and 3, while the estimated results for Eqs. (6) and (7) are the non-linear models which incorporate the interaction of human capital and natural resource rents are reported in models 2 and 4. Before discussing the GMM output, just like Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998), we discuss three specific diagnostics. First, the number of instruments in each model is lesser compared to the number of cross-sections. This infers that the models are free from a proliferation of instrument problems. Secondly, the Hansen test for over-identification reported a statistically insignificant probability value, suggesting that the null hypothesis for the Hansen test is not rejected for all the regressions. Hence, confirming the validity of the instruments. Finally, the result of Arellano-Bond second-order-AR(2) autocorrelation test of residuals is statistically not significant for all the regressions. The null hypothesis of no second-order autocorrelation is not rejected. This indicates that the original errors are serially uncorrelated and the moment condition is correctly specified.

From the controls, the lagged dependent variable (L.HDI) demonstrates a positive and statistically significant impact, across all the models. Previous welfare levels exert a significant and positive influence

Table 3
Test for multicollinearity among the variables.

Variable	Model-1		Model-2	
	VIF	1/VIF	VIF	1/VIF
infrast	3.47	0.288	3.12	0.321
findevt	3.01	0.333	3.00	0.333
humcap	2.17	0.461	-	-
sch	-	-	1.72	0.580
unemploy	1.98	0.504	2.11	0.475
trade	1.89	0.529	2.03	0.493
natres	1.29	0.777	1.45	0.691
democracy	1.28	0.781	1.25	0.797
physcap	1.27	0.788	1.22	0.818
Mean VIF	2.04		1.99	

Source: Authors' construction (2023).

Table 4
Results on the effect of natural resource rents and human capital on welfare (Dependent variable: human development index).

VARIABLES	(Model-1)	(Model-2)	(Model-3)	(Model-4)
	(Sys-GMM)	(Sys-GMM)	(Sys-GMM)	(Sys-GMM)
	HDI	HDI	HDI	HDI
L.HDI	0.918*** (0.0396)	0.913*** (0.0338)	0.932*** (0.0234)	0.996*** (0.0149)
natres	-0.0022*** (5.81e-04)	-0.0076*** (0.00267)	-0.0016** (6.99e-04)	-0.0097** (0.00404)
trade	0.000106** (5.17e-05)	0.000614* (0.000329)	0.000398 (0.000418)	0.000301 (0.000229)
unemploy	-0.00105 (0.00192)	-0.00442 (0.01311)	-0.00302* (0.00149)	-0.00412*** (0.00111)
infrast	3.07e-05 (0.000140)	4.45e-05 (0.000115)	0.000139 (0.000119)	0.000164* (8.76e-05)
findevt	0.0368*** (0.00864)	0.0180** (0.00862)	0.0307** (0.0114)	0.0114 (0.00755)
democracy	0.000578 (0.000392)	0.000696* (0.000390)	0.000528 (0.000402)	0.000151 (0.000302)
physcap	0.00121* (6.80e-04)	0.00133** (0.000530)	0.00112* (0.000622)	0.000603 (0.000597)
<i>Human capital measures</i>				
humcap	0.0103* (0.00507)	0.0215*** (0.00445)	-	-
sch	-	-	0.02992* (0.01489)	0.0170** (0.00800)
<i>Interacting variables</i>				
natres × humcap	-	0.00317*** (0.00056)	-	-
natres × sch	-	-	-	0.000418*** (7.764e-05)
Constant	0.0291*** (0.00588)	0.0112 (0.00816)	0.0303*** (0.00657)	0.0108** (0.00403)
Observations	448	448	448	448
R-squared				
F-statistics	191905.29	243521.75	80425.18	163444.28
Countries	32	32	32	32
Time effect	YES	YES	YES	YES
Instruments	23	24	23	25
Marginal effect	na	-0.002	na	-0.006
Threshold	na	2.40	na	23.21 %
Arellano-Bond test for AR(1)	-3.27 (0.001)	40.43 (0.000)	-3.44 (0.001)	-3.17 (0.002)
Arellano-Bond test for AR(2)	0.15 (0.878)	0.06 (0.949)	-0.15 (0.880)	0.44 (0.658)
Sargan test of OIR:	0.000	0.000	0.058	0.000
Hansen test of OIR:	0.307	0.144	0.150	0.115
<i>Difference-in-Hansen tests of exogeneity of instrument subsets</i>				
Hansen test excluding group	0.239	0.109	0.125	0.104
Difference (null H = exogenous)	0.915	0.655	0.468	0.347
<i>Instrument variables</i>				
Hansen test excluding group:	0.188	0.213	0.188	0.244
Difference (null H = exogenous)	0.457	0.179	0.211	0.128

Author's construction, 2023. ***, **, *, indicate 1%, 5% and 10% significance levels. OIR: over-identifying Restrictions Test.

on the current period's human well-being. Demonstrating the persistence of human welfare advancement among the SSA countries, which supports the findings of Nomba et al.'s (2022a,b) study. Having better welfare in the previous years has cumulative advantages (i.e., over time, initial advantages lead to further advantages), such that countries with

higher welfare in the past may attract more foreign investment, develop better institutions, and establish stronger human capital. These initial advantages create a self-reinforcing cycle of continuous improvement. From Model 1 in Table 4, we observed that trade openness, infrastructural development, financial sector development, physical capital investment, democracy and human capital foster quality human lifestyle in SSA.

For instance, the estimated coefficient of trade openness is positively signed and statistically significant. A percent increase in openness is associated with about 0.011 % appreciation in human progress. Although these findings contradict Onakoya et al. (2019), study, it is consistent with the empirical works of Nomba et al. (2022a,b) and the standard trade theories which highlight that trade openness raise global welfare by increasing market potentials for goods that countries are efficient in producing. International trade gains such as capital flows, labour migration, market expansion, technology diffusions, and information transfers, contribute towards human progress augmentation. Trade openness provides indigenous firms the opportunity to access more global markets, which makes domestic firms efficient, competitive and innovative in the international markets. Despite the region's integration into the global market, the impact of trade on human development in SSA is quite low, as shown by the trade coefficient. Domestic constraints such as weak institutions, an underdeveloped manufacturing sector, low savings, over-reliance on raw materials for exports, and elastic demand for foreign-produced goods, coupled with external factors like exchange rate volatility may explain the region's lower gains from trade.

Further, unemployment rate is negative and statistically significant to human well-being (models 3 and 4). A percent upsurge in the unemployment rate on average deteriorates well-being significantly by 0.302 and 0.412 %, which is consistent with expectations and confirms the earlier works of Jongbloed and Giret (2020) and Sulemana et al. (2021). Individual well-being is lower among the unemployed, especially the youth (Jongbloed & Giret, 2020). Psychological distress increases whilst self-esteem among the unemployed declines. The few employed are again burdened with a high dependency which affects their ability to meet the basic sustaining human needs and sense of worth. The inferior economic status deepens deprivation and inculcates a vicious poverty cycle.

The GMM estimates show that infrastructural development on human prosperity cannot significantly be confirmed, except in the last column, where infrastructural development is observed to contribute positively towards a better life. Improving the infrastructural base either by investing in transport and energy, water and sanitation or ICT sectors improves quality lifestyle. Investing in quality water and sanitation, for instance, supports health outcomes (Pickbourn & Ndikumana, 2019). Poor health and sanitation exert detrimental consequences on socio-economic development. Mortalities due to respiratory infections and waterborne diseases may upsurge.

Financial development stimulates human progress as proven by the estimated coefficient in models 1, 2, and 3. Expansion in the financial markets and financial institutions in terms of size, accessibility, and efficiency could boost the development of human well-being. As displayed in models 1, 2 and 3, on average, human well-being escalates by 0.037, 0.018, and 0.031 % if the financial sector progresses by 1 %. This empirical finding is consistent with capital accumulation theory and the empirical findings of Rahim et al. (2021) and Amoaning and Ahikpor (2022). A developed financial institution tends to reduce information asymmetry due to an increase in information-sharing offices such as public credit registries and private credit bureaus among financial institutions. This enables financial institutions to mitigate the challenge of adverse selection, hence mobilized deposits to the deficit households and businesses, have a lesser risk of default.

Similar to Mohammed (2021), the connection between democracy and welfare is positive, although not statistically significant, except for model 2. Democracy advocates for accountability and transparency,

which enforces rule of law, reduces political instability, and promotes economic freedom that creates an enabling environment for domestic and foreign investors. Countries that are less democratic, usually have high political unrest. Investors may hold on to their investments due to fear of losing their investment in the case of an overthrow of a political leader. The perception affects the region's income distribution and general well-being. Finally, a percentage increase in physical capital stimulates human well-being at an average rate of 0.001 units (see models 1 and 2). This outcome on capital accumulation is in line with Aslan and Altinoz (2021); and Ntamwiza and Masengesho (2022). Increase in capital stock due to capital equipment investment, either economic and social infrastructure surge production, which finally raises employment opportunities, and intensifies technological diffusion and technological growth. These intensified economies of scale provide mechanisms to equip human capital development, which could escalate productivity, economic growth and human welfare.

On our interest variables, from models 1 and 3, life quality is induced at an average rate of 0.010 and 0.030 units, if the human capital variables, measured by the human capital index and tertiary school enrollment, appreciate by 1 unit and 1 %, respectively. This outcome is parallel to the human capital theorem and Rahim et al's. (2021) empirical findings. Investing in education causes labour to be more productive, innovative, and research-oriented, which augment productivity in the long run. This will finally synthesize economic growth and elevate people from deprivation. Economic agents can afford more nutritious food and acquire better housing and quality medical care, hence promoting a healthy lifestyle and better life expectancy.

On the first objective, as displayed in the linear models, natural resources demonstrate a significant negative impact on human well-being. In model 1 for instance, a percent increase in natural resource rents causes a decline in human welfare at an average rate of 0.002 units or 0.2 %. An indication that rents received through natural resource exploitation have a dampening effect on well-being in SSA. This confirms the resource curse hypothesis and the "Dutch disease" phenomenon and equally justifies the inability of the subregion to fully make judicious utilization of the rents accrued from natural resources exploit to boost socio-economic development. Although our findings contradict Smith and Ricardo's perception and the recent empirical findings of Bwana and Tumaini (2022) and Musibau et al. (2022), it corroborates the findings of Aslan and Altinoz (2021), Rahim et al. (2021), Tabbash et al. (2022) and Nomba et al. (2022a,b). Natural resource rents may raise domestic revenue but their inability to produce the expected positive spill-over effect on human well-being progress can be attributed to internal constraints, including overdependence on natural resources exports (i.e., supply chain), ineffective government, rent-seeking behaviours of influential individuals', resource movement effect, spending effect, the laws of the state, political disputes, conflicts over share controls and excessive reliance on the mining sector resulting in the neglect of the other economic sectors.

Interpreting the interactive effects

What happens to human welfare when there is an improvement in a producible capital like human capital? In response to the question, we concentrate on the non-linear models. From models 2 and 4, the human capital measures, natural resource rents and interaction terms are statistically significant. The positive signs of the interactions (0.003 and 0.0004) indicate that improvement in human capital might offset the negative impact resource rents have on human welfare in SSA. To illustrate the partial effect of natural resources on human welfare given the human capital value, we compute the marginal effects using Eqs. (10) and (11). Beginning with the human capital index, the effect of natural resource rents on human welfare, conditioned on the region's average human capital level is (-0.002) . Which is computed as:

$$\frac{\partial(HDI_{it})}{\partial(natres_{it})} = [(-0.0076) + (0.0032) \times (1.817)] \approx -0.0018.$$

Where -0.0076 and 0.0032 are the unconditional effect and the indirect effect

of natural resource rents on well-being, and 1.817 is the average human capital score. The marginal elasticity of -0.002 implies that even at an average level of human capital, a percent increase in natural resource rents negatively induces human welfare by 0.2 %. Comparing the unconditional effect (-0.0076) to the marginal effect (-0.002), it could be deduced that there is some level of improvement in human welfare which is attributed to human capital development, even though the recorded average human capital value is not sufficient to avert the curse.

Similarly, with tertiary school enrollment rate as an alternative human capital measure, the marginal effect computed from model 4 [$-0.0097 + (0.0004 \times 8.686) = -0.006$], demonstrates that the effect of resource rents on welfare at the average rate of tertiary school enrollment is negative. Where 8.686 % is the average rate of enrollment into tertiary education and -0.0097 and -0.006 are the unconditional effect and the marginal impact of the interaction. All things remain constant, a percent increase in rents from natural resources contributes about 0.6 % decline in human welfare, given the average rate of enrollment into tertiary education. Again, comparing the unconditional effect to the marginal effect, it is perceived that there is a joint favourable economic influence stemming from natural resource rents and human capital enhancement. The higher the average level of human capital score or school enrollment rate in SSA, the lesser the magnitude of the adverse impact of natural resource dependence on human welfare. Developing human resources through formal or informal training reduces information gap as well as the technology gap, which can be translated into value addition. An indication that trained and skilled economic agents ensure efficient extraction and judicious use of revenues from natural resources to augment human lifestyle. This justifies that for a natural resource to be a blessing or a curse, strongly depends on the knowledge level or human resource quality.

Now, from the estimated regressions in models 2 and 4, we compute the threshold level of human capital that is sufficient to avert the resource curse. After differentiating the estimated result in model 2 with respect to resource rents, the threshold value for human capital is obtained as: $\frac{\partial(HDI_t)}{\partial(mates_t)} = -0.0076 + 0.003humcap \geq 0, \Rightarrow humcap \geq 2.40$. The computed threshold level of human capital is about 2.40 units, which falls within the human capital ranges provided in the descriptive. It implies that when the human capital index is above the 2.40 threshold score, the resource curse could turn into a blessing. Alternatively, using tertiary school enrollment as a measure of human capital, as demonstrated in model 4, the threshold level is roughly equal to 23.21 % ($\frac{\partial(HDI_t)}{\partial(mates_t)} = -0.0097 + 0.0004sch \geq 0, \Rightarrow sch \geq 23.21\%$). It justifies that the level of human capital measured by tertiary school enrollment, should be equal to or greater than 23.21 % to offset the adverse effect of natural resource rents on human welfare among SSA countries. In other words, higher enrollment in tertiary education can help mitigate the adverse effects of relying on natural resource rents for SSA countries. It implies that investing in education and human capital development is crucial in ensuring that resource rents contribute positively to human welfare. The results discussed validate the forecasts made by [Eslam-loueyan and Jafari \(2021\)](#) and [Djokoto \(2022\)](#), highlighting the essential role of adequate human capital in preventing the resource curse.

Robustness check, using poverty rate as the dependent variable

To validate the robustness of our findings, akin to [Fambeu \(2021\)](#), we employ a monetary human well-being indicator as the dependent variable. The estimated system GMM presented in [Table 5](#) remains stable, similar, and consistent with our main results. Specifically, our analysis underscores that the region's reliance on natural resources and an upswing in unemployment exacerbate poverty, thereby compounding economic woes. Further, physical capital investment, democracy and human capital development emerge statistically significant in diminishing poverty. Additionally, trade openness, infrastructural development and financial sector progress lack statistical significance in

Table 5
Robustness check, using poverty rate as the dependent variable.

VARIABLES	povati190	povati190	povati190	povati190
l.povati190	0.969*** (0.0125)	0.997*** (0.0130)	0.973*** (0.0111)	0.989*** (0.00482)
natres	0.0259** (0.00957)	0.0261* (0.0129)	0.311*** (0.0663)	0.138* (0.0686)
trade	-0.000449 (0.00472)	-0.00379 (0.00542)	-0.00895* (0.00523)	-0.000370 (0.00705)
unemploy	0.0708*** (0.0133)	0.00338 (0.0206)	0.0197 (0.0181)	0.00983 (0.0212)
infrac	-0.0108 (0.0217)	-0.00766 (0.0166)	-0.0123 (0.0195)	-0.0181 (0.0183)
findevt	-0.465 (1.421)	-0.724 (1.160)	-3.836*** (1.335)	-0.426 (1.109)
democracy	-0.0279*** (0.00663)	-0.0203*** (0.00424)	-0.0280*** (0.00740)	-0.0227*** (0.00427)
physcap	-0.0802*** (0.0160)	-0.0266*** (0.00935)	-0.0424*** (0.0123)	-0.00603 (0.0143)
humcap	-0.299** (0.134)		-1.628** (0.638)	
sch		-0.445*** (0.158)		-0.126*** (0.0200)
natres × humcap			-0.133*** (0.03005)	
natres × sch				-0.00706** (0.00269)
Constant	3.507*** (1.052)	2.164** (1.054)	-0.202 (1.121)	0.268 (1.446)
Fisher's statistic	71223.21	366189.38	116045.03	101028.76
Marginal effect			0.069	0.077
Threshold			2.34	19.55 %
Instruments	28	29	29	29
Observations	416	416	416	416
Time effect	YES	YES	YES	YES
R-squared				
Countries	32	32	32	32
Arellano-Bond test for AR(1)	-0.99 (0.320)	-1.11 (0.268)	-1.54 (0.125)	-1.21 (0.225)
Arellano-Bond test for AR(2)	-0.78 (0.434)	0.31 (0.759)	0.68 (0.495)	-1.09 (0.275)
Sargan test of overid. restrictions	0.000	0.000	0.000	0.000
Hansen test of overid. restrictions	0.133	0.216	0.160	0.181
<i>Difference-in-Hansen tests of exogeneity of instrument subsets:</i>				
Hansen test excluding group:	0.51 (0.474)	0.18 (0.912)	0.30 (0.586)	0.11 (0.737)
Difference (null H = exogenous):	23.02 (0.113)	22.18 (0.137)	22.39 (0.131)	21.99 (0.144)
<i>Instrument variable (IV)</i>				
Hansen test excluding group:	7.99 (0.239)	22.18 (0.137)	8.67 (0.123)	8.68 (0.122)
Difference (null H = exogenous):	15.54 (0.159)	12.39 (0.415)	14.94 (0.185)	13.42 (0.340)

Author's construction, 2023. ***, **, *, indicate 1%, 5% and 10% significance levels. Note: The values in parenthesis reported under diagnostics are the probability values. OIR: over-identifying Restrictions Test.

contributing to poverty alleviation, despite their reported negative coefficients. An indication that these variables bear the potential to reduce poverty within the selected countries. The coefficients associated with democracy are convincing enough to conclude that higher democracy practice will raise the standard of living of the vulnerable. Through the electoral process, democracy gives the poor the privilege to penalize governments that may create poverty, economic hardship, and famine. Political leaders knowing the powers accorded to voters may act

strategically and institute policies that could avoid this socioeconomic stress.

In alignment with objective 1, a rise in natural resource rents intensifies deprivation, as evidenced by the positively significant coefficient. This outcome aligns consistently with the findings reported by Mueller (2022). The crowding-out of growth in other salient sectors, neglect of human development, dependence on foreign expertise for resource management, weak institutions, lack of economic diversification, low transparency and accountability, unequal bargaining power with foreign firms and conflicts, which may be attributed to low human capital development might contribute to the region's inability to reduce poverty through natural resource gains. Further, continuous extraction in an attempt to increase rents is negatively impacting climate change, which is gradually reducing the region's per capita output and food supply. Climate change is not only exacerbating food prices but amplifying vulnerabilities of communities whose livelihood directly depends on the environment.

Human capital indicators, both the human capital index and tertiary school enrollment, contribute to poverty alleviation, affirming to our main finding that developing human capital has the potential of sustaining socio-economic progress in SSA. This is demonstrated in the net effect as well. The computed net effect is derived from columns 3 and 4, which is given as:

$$\frac{\partial(\text{poverty}_{it})}{\partial(\text{matres}_{it})} = [(0.311) - (0.133) \times (1.817)] \approx 0.069$$

where 0.311 and -0.133 are the unconditional and conditional effects of natural resources. The positive net effect of 0.069 is an indication that the average human capital score is not sufficient to avert the natural resource contribution in alleviating poverty. For a natural resource to reduce poverty, the human capital score should exceed the computed threshold of 2.34 points $\left\{\frac{0.311}{0.133}\right\}$

Similarly, with enrollment rate into tertiary education as the alternative human capital variable, the unconditional effect and the conditional effect are 0.138 and -0.007 , respectively. As shown by the computed positive net effect $\left(\frac{\partial(\text{poverty}_{it})}{\partial(\text{matres}_{it})} = [(0.138) - (0.007) \times (8.686)] \approx 0.077\right)$, at the average enrollment rate into tertiary education, natural resource rents may deepen poverty by about 0.077 %, which is relatively less compared to the 0.14 % deprivation reported by the unconditional effect. However, the threshold level of tertiary education enrollment rate which may inculcate natural resources to perhaps alleviate poverty should exceed 19.55 %.

Conclusion and recommendations

Inspired by sub-Saharan Africa's desire to improve human welfare and reduce poverty with its resource wealth, we contributed to the literature on the resource curse by drawing annual data from 32 selected SSA countries for the period 2004 to 2019. Using the system GMM estimation technique, we first examined the impact of natural resource rents on human socioeconomic prosperity as well as the mediating role of human capital development in the natural resource rents-human welfare link. Further, we examined the threshold level of human capital above which the resource curse turns into a blessing. Finally, we provided robust evidence from the system GMM estimator using a monetary deprivation measure as the dependent variable.

First, evidence of a resource curse is confirmed, suggesting that gains from natural resources impede human progress in SSA. Furthermore, investing in human capital development not only contributes

enormously towards eradicating deprivation, but it also moderates the negative repercussions emanating through natural resource-well-being links and probably averts the curse into a blessing. Thirdly, a higher human capital score and tertiary school enrollment above 2.4 units and 23.21 % thresholds respectively, may avert the prosperity curse. Again, for a natural resource to lighten the poverty rate, human capital score and tertiary school enrollment rate should exceed the threshold of 2.34 points and 19.55 %. Finally, international trade participation and democracy were found to synthesize human prosperity.

The vital policy implication deduced from this study is that policy-makers should strive to align natural resource management policies with human capital development strategies. According to this study, to ensure natural resource-development blessings, government should prioritize increased investment in education, aiming to surpass the estimated threshold level of 23.21 % for tertiary education enrollment. Furthermore, the Ministry of Education should implement policies that will increase the years the productive unit spends in schooling, aiming to elevate the human capital score above 2.4 points. This is crucial for overcoming inefficiencies in the natural resource utilization and maximizing the positive impact of natural resource rents on human development outcomes. Additionally, governments in SSA should focus on investing in research and development programmes to enhance international trade gains, promote economic diversification and fortify democratic system. Such efforts will not only synthesize human progress but sustain it for the future.

Since the gains from natural resource exports can trigger human development depending on the type of commodity a country specializes in, future research should explore the resource curse literature by classifying the full sample into two sub-groups based on the commodity types an economy specialized in exporting. Thus, those that specialize in non-renewable natural resource exports and those that specialize in renewable or non-resource exports (particularly, agricultural products), assess which threshold boundary to set for each group. Further, we can include investment in human health as an additional moderating variable for human capital since it can have a desirable effect on labour efficiency to increase natural resource rent management. This further study builds on the principle that natural resource rents have a link with human capital which can be a probable pathway to human prosperity. However, it is important to acknowledge the limitations of this study. The availability of data is a primary constraint. Although the sub-Saharan African region comprises 48 countries in total, this study only covers data from 32 countries. It is worth noting that the excluded countries could potentially impact the magnitude of the findings.

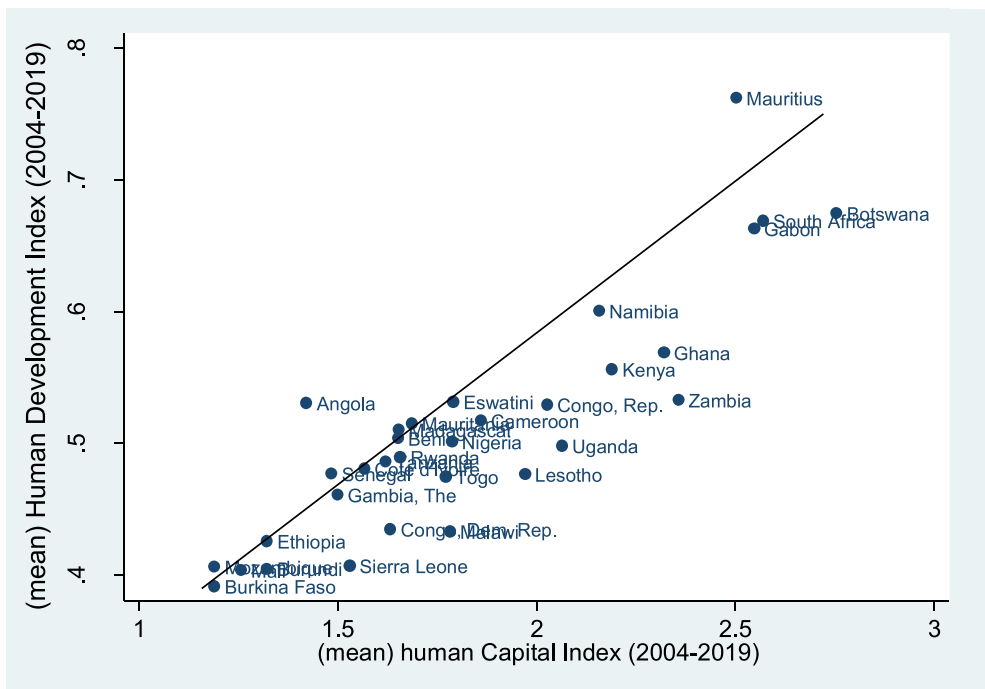
CRediT authorship contribution statement

Felix Amoaning: Software, Methodology, Formal analysis, Data curation, Conceptualization, Writing – original draft. **Camara Kwasi Obeng:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – review & editing. **William Godfred Cantah:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix 1. Mean human capital and human development in SSA



Appendix 2. List of countries selected for the study

Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Congo, Dem. Rep., Congo, Rep., Cote d’Ivoire, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mauritania, Mauritius, Mali, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Uganda, Zambia.

Appendix 3. Correlation matrix

	natres	humcap	inveduc	trade	unemploy	infrast	findevt	democracy	physcap
natres	1.000								
humcap	-0.118	1.000							
inveduc	-0.278	0.297	1.000						
trade	0.187	0.326	0.440	1.000					
unemploy	-0.065	0.507	0.512	0.577	1.000				
infrast	-0.318	0.653	0.211	0.137	0.437	1.000			
findevt	-0.335	0.576	0.340	0.198	0.395	0.712	1.000		
democracy	0.154	-0.273	-0.215	-0.222	-0.188	-0.164	-0.366	1.000	
physcap	0.236	0.152	0.081	0.355	0.080	-0.095	-0.004	-0.112	1.000

Source: Authors’ construction.

Appendix 4. Hadri (2000) panel stationarity test results

Variables	z-statistic	p-value
HDI	24.434	0.000
povati190	26.892	0.000
natres	10.333	0.000
humcap	29.694	0.000
sch	20.770	0.000
trade	14.330	0.000
unemploy	20.180	0.000
infrast	13.475	0.000
findevt	12.702	0.000
democracy	9.126	0.000
physcap	14.683	0.000

Sources: Authors’ calculation.

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