Food and Agriculture Organization of the United Nations

Digitalization and child labour in agriculture

Exploring blockchain and Geographic Information Systems to monitor and prevent child labour in Ghana's cocoa sector

DESIGN PAPER

WAGENINGEN UNIVERSITY & RESEARCH

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Exploring blockchain and Geographic Information Systems to monitor and prevent child labour in Ghana's cocoa sector

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Abbreviations and acronyms

ACE – Action Against Child Labour

AHTU – Anti Human Trafficking Unit

CCLMS – community child labour monitoring system

CCPC – Community Child Protection Committee

CHPS – Community-based Health Planning and Services

CIC – cocoa identification cards

CLC – Child Labour Committee

CLFZ – Child Labour Free Zone

CLMRS – Child Labour Monitoring and Remediation System

CLU – Child Labour Unit

CMS – Cocoa Management System

COCOBOD – Ghana Cocoa Board

CSO – community support officer

CTE – critical tracking event

DCPC – District Child Protection Committee

FAO – Food and Agriculture Organization of the United Nations

FSNMS – Food Security and Nutrition Monitoring System

GCLMS – Ghana Child Labour Monitoring System

GIS – Geographic Information Systems

ICI – International Cocoa Initiative

ICT – information and communication technology

ILO – International Labour Organization

IPCC – Intergovernmental Panel on Climate Change

JICA – Japan International Cooperation Agency

KDE – key data element

LBC – licensed buying company

MESW – Ministry of Employment and Social Welfare

MPI – Multidimensional Poverty Indicator

NGO – Non-Governmental Organization

NORC – National Opinion Research Centre at the University of Chicago

NPA – National Plan of Action

PPRC – Producer Price Review Committee

UNICEF – United Nations Children's Fund

WUR – Wageningen University & Research

Figures and tables

Preface

The elimination of child labour is embedded in Sustainable Development Goal 8.7. With 70 percent of child labour found in agriculture, this goal cannot be achieved without rapid progress in reducing and eliminating child labour in this sector. Child labour hinders global efforts to end rural poverty and hunger and ensure sustainable agrifood systems. In light of its sectorial prevalence, the Fifth Global Conference on the Elimination of Child Labour, held in May 2022 in South Africa, placed the elimination of child labour in agriculture at the core of its outcome document, the Durban Call to Action.

This design paper is the result of an outstanding collaboration between the Food and Agriculture Organization of the United Nations (FAO) and Wageningen University & Research (WUR) in establishing a robust digital framework aimed at fostering the promotion of agrifood value chains free from child labour. It demonstrates the powerful impact of combining science, technology and innovation to contribute to the achievement of the Sustainable Development Goals.

Through a country and value chain-specific lens, the paper explores the potential of blockchain technology and Geographic Information System to assess a data framework made of selected child labour risk indicators, thereby estimating the risk faced by cocoa-growing farmers and their families to become functionally or economically dependent on child labour.

Attempting to address a serious challenge through a breakthrough technology is sometimes referred to as a "moonshot". This report represents an example in that sense: addressing child labour in agriculture through digital methodological framework involving innovative tools. The results presented in this report are a starting point to harness the potential of digital technologies for accelerating progress in the elimination of child labour.

With this publication, FAO and WUR aim to contribute to the collective effort of addressing child labour in agriculture through technological solutions and to catalyse a broader discussion and investments in digitalization for child labour monitoring and remediation along agrifood value chains.

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Summary

This paper is the product of a collaboration between the Food and Agriculture Organization of the United Nations (FAO) and Wageningen University and Research (WUR) to explore the potential application of innovative technologies to improve data collection and risk estimation of child labour in the cocoa sector. In particular, it assesses the potential role of blockchain technology and Geographic Information Systems (GIS) in collecting and sharing data on cocoa-growing areas in Ghana, and how this could contribute to monitoring and ultimately preventing child labour in those areas. During an inception mission undertaken by FAO in Ghana, open consultations with various stakeholders in the cocoa sector led to the identification of a number of Key Data Elements (KDEs) to inform the design of a blockchain system, with the objective to facilitate real-time, cost-efficient and collaborative monitoring of the risk of child labour in cocoa-growing areas in Ghana. WUR was commissioned by the FAO to further explore the potential application of blockchain technology and GIS to monitor selected KDEs related to the root causes of child labour in Ghana.

Despite decades of interventions since the ratification of the Harkin-Engel Protocol in 2001 to eliminate child labour in the cocoa sectors of Côte d'Ivoire and Ghana, the latest progress report shows child labour in this sector is increasing rather than decreasing (Sadhu *et al.*, 2020). This trend is concerning, given the detrimental effects of child labour on children's lives, education and health and the perpetuated cycle of poverty as a result. To break this trend, it is necessary to expand and improve current methods of tracking the incidence of child labour (monitoring) and explore more sustainable ways to support rural families to keep children out of child labour (prevention).

To that end, technology, digitalization, and digital innovations have a role in poverty reduction and improving living standards in developing countries, although political and economic problems can hinder these technological fixes. With smallholder cocoa producers being the most vulnerable actors within this value chain, the implementation of technological monitoring systems is not a clear-cut route. Participation and engagement depend not only on the perception of the advantages to farmers and community, but also on issues that impact the adoption and use of information and communications technologies (ICT). For example, availability, affordability, and literacy and effective use.

Currently, monitoring of child labour in cocoa takes place on both industry and national levels and has several applications, such as quarterly or annual risk models, monitoring and remediation systems and the implementation of Child Labour Free Zones (CLFZs). Data collection

takes place through direct observation, through monitoring visits and household surveys. Based on stakeholder interviews and an overview of current monitoring practices in Ghana, the following challenges are identified:

Cost: household visits are costly, as it needs direct observation by trained staff.

Coverage: the majority of cocoa households are currently not covered by any monitoring system.

Timing: monitoring through direct observation is time-consuming.

Limited data and information sharing: despite that many monitoring systems, risk models and pilots exist, there is no central database where information is collected and shared.

Digital exclusion: remote cocoa-growing areas lack digital infrastructure.

Blockchain systems and GIS could contribute to addressing some of these challenges. Depending on their application, innovative technologies could facilitate ease of data sharing and collaborations and risk estimation of areas not covered by current monitoring systems, acting as a backbone for data capture, validation, management and sharing information. The applicability would rely on the quality and relevance of the data points entered in the blockchain. The paper explores a series of KDEs reflecting the typical root causes of child labour in agriculture, which can either be tracked directly, or through GIS and satellite images with forecasting potential. The combination of these data elements can provide risk estimations in cocoa-growing areas where direct observation is either not present or difficult to achieve.

Although blockchain and GIS techniques are promising, a number of issues need to be considered before application is feasible. In particular, the scattered stakeholder field, potential effects on cocoa-growing households and costs require further exploration and collaboration among stakeholders. In addition, the introduction of a blockchain system built upon selected KDEs would need to be based on a solid dataset modelling with clear layering, weighting and scoring of the risk indicators, allowing for the desired child labour risk estimation.

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1. Introduction

The prevalence of child labour in the cocoa sector in Ghana and Côte d'Ivoire has increased since 2009. According to the latest estimates by the National Opinion Research Center at the University of Chicago report – known as the NORC report (Sadhu *et al.*, 2020) – there are approximately 1.56 million children engaged in child labour in cocoa production in Ghana and Côte d'Ivoire, of which 1.48 million children engaged in hazardous work. In Côte d'Ivoire and Ghana in aggregate, the prevalence of child labour in cocoa production among all agricultural households increased by 14 percentage points between 2008-2009 and 2018-2019, despite efforts and commitments from the side of the government and international chocolate companies to eliminate the worst forms of child labour. Although part of the increase could be due to the simultaneous increase in cocoa production during the assessment period, the figures suggest that as cocoa production increased and cocoa farming expanded in historically lower cocoa growing areas, the use of child labour in those areas also expanded (Sadhu *et al.*, 2020).

Child labour in agriculture is both cause and consequence of rural poverty and hunger, creating and perpetuating poverty traps known as 'vicious cycles of child labour in agriculture' (FAO, 2020a; Lambon-Quayefio and Owoo, 2021). Working from an early age significantly reduces children's future earnings and increases the odds of choosing low-skilled occupations later in life (Lambon-Quayefio and Owoo, 2018). To turn this vicious cycle into a virtuous cycle of education and decent rural employment, it is necessary to address the drivers of farmers' functional and economic dependency on child labour, including poor livelihoods, malnutrition, barriers to education and decent work and vulnerability to climate change-related events. Innovation and digitalization have potential to play a key role in addressing these drivers, by accelerating and upscaling the elimination of child labour in agriculture. Innovative technologies, such as blockchain, could provide the efficiency and transparency necessary to monitor the risk of child labour in an integrated manner, and thereby allow the upscaling of resources for remediation efforts to ensure children stay out of child labour. This paper explores how this could work in the context of Ghana's cocoa sector in an integrated manner, and thereby allow the upscaling of resources for remediation efforts to ensure children stay out of child labour.

The focus on Ghana's cocoa sector emerges from the country's leading role in cocoa production and trade globally and prevalence of child labour in the sector. The cocoa sector in Ghana employs about 800 000 farm families (across 6 production regions), most of whom are in rural locations. As a second-

leading world cocoa producer, Ghana has registered an annual minimum cocoa beans output of 700 000 metric tons since 2012 (Sasu, 2022). Ghana's economy is anchored by cocoa, which contributes about 30 percent of foreign exchange earnings to the country. Together with Côte d'Ivoire, Ghana accounts for 60 percent of global cocoa production and is a major supplier to the European Union, which is the world's largest importer of cocoa, accounting for 60 percent of world imports (European Commission, n.d.). Against this background, and in the context of the European Commission's zero-tolerance policy on child labour, the European Union-funded Sustainable Cocoa Initiative is supporting Ghana to enhance the sustainability of its cocoa sector, including by eliminating child labour along the country's cocoa value chains.

Since 2000, the Government of Ghana has undertaken strenuous efforts to establish a sustainable legal and institutional framework to eliminate child labour, especially its worst forms. Ghana was the first to ratify the UN Convention on The Right Of The Child and also ratified the ILO Convention 182 on Worst Forms of Child Labour, the ILO Minimum Age Convention (138) and the ILO Forced Labour Convention (No 29), among others. These conventions have been domesticated into Laws like the Children's Act 1998 (Act 560) and the Labour Act 2003 (651). These laws influenced the development of several policies and programmes, among which the Time-Bound Project and the West Africa Cocoa and Commercial Agriculture Project (WACCAP), both under the ILO's International Program for the Elimination of Child Labour (IPEC). The two initiatives were instrumental in setting the tone for a more purposeful action towards the elimination of child labour in Ghana. In a direct response to the growing incidence of child labour in cocoa, the government of Ghana under the Ministry of Employment and Labour Relation established the National Programme for Elimination of Worst Forms of Child labour in Cocoa (NPECLC) in 2006. This collaboration with external partners led to the development of the Hazardous Child Labour Activity Framework (HAF) for the Cocoa Sector in 2008 and the latest Hazardous Child Labour List for Ghana (GHAHCL) in 2016.

In 2009, the first National Plan of Action (NPA1) on the Elimination of the Worst Forms of Child Labour (2009-2015) was implemented, which led to significant progress in terms of public awareness and support to many affected children. However, child labour persists and is endemic in many communities, especially deprived ones. As a result, a second National Plan of Action (NPA 2: 2017-2021) was developed, demonstrating the persistent national effort to address the challenge (ICI *et al.*, 2017). In addition, Ghana is a pathfinder country of the Alliance 8.7, having committed to go further and faster to achieve SDG Target 8.7, which aims to eliminate child labour in all of its forms by 2025 (Alliance 8.7, n.d.).

Compliance on child labour regulations will be part of new European Due Diligence frameworks. In December 2022, the European Union Council and the Parliament reached a provisional agreement for a regulation on deforestation free supply chains. The goal of this

regulation is to minimize the risk that products originating from supply chains associated with deforestation enter the European Union market, and to increase the demand for deforestation-free products. It will help achieve mandatory due diligence obligations for operators placing commodities and products on the European Union market or exporting from the European Union, including cocoa. As part of the commitment to achieve this, verification of compliance will be performed by authorities, with frequency of checks to be varied based on the risk level (low/standard/high) of the producer country, assessed through a benchmarking process. Products would be required to be traceable, deforestation free, and produced in consonance with the legal frameworks of the producing country. The legal due diligence includes compliance with child labour regulations. Increasing transparency in the cocoa chain is not only necessary to eliminate hazardous child labour in cocoa production, it will become mandatory.

The objective of this paper is to understand the challenges of current monitoring systems and explore whether novel technologies, such as blockchain, may address them. The aim is to explore the potential of blockchain to inform the design of risk mappings for addressing the drivers of child labour in Ghana's cocoa-growing communities. This paper builds on FAO's inception mission to Ghana in 2019. The resulting findings and follow up discussions led to the identification of Key Data Elements (KDEs) that could be registered at critical tracking events (CTE) in a blockchain system as indicators of child labour risk. This paper addresses these and other KDEs in the context of a blockchain application. Our methodology consists of a desk review of reports on child labour in the cocoa sector in Ghana, current monitoring systems, and a number of blockchain applications so far applied in the cocoa sector. This information is complemented with semi-structured interviews with key stakeholders, focusing on the key root causes of child labour, challenges and opportunities in current monitoring systems and key stakeholders to involve in the design of new monitoring systems.

Box 1: Definition and prevalence of child labour

The definition of child labour is set by the Minimum Age Convention, 1973 (No. 138) and the Worst Forms of Child Labour Convention, 1999 (No. 182), which is the first ILO Convention to achieve universal ratification. Additional guidance is provided in the related Minimum Age Recommendation, 1973 (No. 146) and the Worst Forms of Child Labour Recommendation, 1999 (No. 190). Protecting children from economic exploitation is also included in the Convention on the Rights of the Child, 1989, Article 32. These conventions mandated member countries to domesticate laws that will address the issues within the convention. Ghana legislated laws like the Children's Act 569 and the Labour Act 651 together with its accompanying legislative Instruments. Prior to these laws which were mostly influenced by international conventions, the 1992 Constitution and the Criminal Code (Amendment) Act, 2003 (Act 646) had provisions that protects the interest of children and labour related issues.

According to this normative framework, child labour is commonly defined as work that is inappropriate for a child's age, affects children's education, or is likely to harm their health, safety or morals. In Ghana, the Children's Act, Act 596 refers to exploitative child labour as work that deprives the child of its health, education or development. Some literature or definitions, use words such as exploitative or hazardous to contextualize the definition as in the case of Ghana. However, it is important to understand that child labour does not refer to age-appropriate tasks that are not hazardous and do not interfere with a child's education. On the contrary, these tasks can be helpful for a child to acquire agricultural and life skills for their future, to ensure inter-generational knowledge transfer and can contribute to their family's livelihood.

At the global level, in 2020 ILO and UNICEF estimated that 160 million (+5 percent compared to 2016) children are engaged in child labour (almost 1 in 10 of all children worldwide). The largest share of child labour (70 percent) persists in agriculture, the only sector where child labour is increasing, accounting for 112 million girls and boys (+4 million since 2016). Age-wise, over three-quarters of all children aged 5 to 11 are in child labour in agriculture (+13.3 percent since 2016). This underscores agriculture as the main entry point to child labour for the youngest group of children, a group for whom the physical demands and hazards of farm work can be particularly damaging.

While child labour is more prevalent among boys than girls at every age, when household chores are considered, such as water collection, the gender gap in prevalence among boys and girls aged 5 to 14 is reduced by almost half. Of all children in child labour in agriculture, 43 percent (48.1 million children) are involved in hazardous work in agriculture, reaching 67.1 percent for the 5-14 age cohort. Hazardous work is defined as work that is likely to harm the health, safety or morals of a child (Article 3[d] of ILO Convention No. 182) and belongs to the worst forms of child labour. Lastly, 72.1 percent of all child labour lies in family work (+8.7 percent since 2016), with hazardous work accounting for a substantial portion of family work (28.6 percent for 5-11 and 47.2 percent for 12-14), counter to the common perception of the family as a safer working environment.

From a regional lens, Sub-Saharan Africa stands out as the region with the highest prevalence and the largest number of children in child labour in general. There are now more children in child labour in sub-Saharan Africa (86.6 million) than in the rest of the world combined. When it comes to sectorial disaggregation, 81.5 percent of all child labour in Sub-Saharan Africa is in agriculture. The dynamics in Ghana are similar to the global and sub-regional level. As data on child labour is often scattered or not available, the most comprehensive data on child labour in Ghana is the Child Labour Survey 2001. Despite this limitation in data collection, the 2021 Ghana Population and Housing Census indicates that 3.2 percent children (5-14 years) are engaged in economic activity with a substantially higher proportion in rural areas (5.7 percent) compared to urban (1.0 percent). Among these children aged 5-14 years engaged in economic activity, there are about 80 percent of them involved in agriculture-related activities with the highest (89.8 percent) proportion in Savannah Region.

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2. Child labour in Ghana's cocoa sector: specificities and current monitoring systems

Prior to exploring the potential application of blockchain in addressing the challenges in child labour monitoring, it is important to fully understand the root causes of child labour in Ghana and the current monitoring systems in place. This chapter starts by exploring the root causes of child labour in Ghana, then discusses current monitoring systems and derives five key challenges to be addressed.

2.1 Root causes of child labour in cocoa in Ghana

The root causes of child labour are multidimensional and relate to economic, socio-cultural and institutional factors. Poverty is among the key drivers of the prevalence of child labour in cocoa production. In addition, several other factors impact parents' decisions to engage their children in farm work, ranging from the structure of the (local) economy, labour intensity and diversity of tasks required, socio-cultural influences, local labour market dynamics, institutions and the seasonal demand for agricultural work (Krauss, 2017). Even historical events have contributed to the current situation. Cocoa was introduced to Ghana in the 19th century, when European missionaries encouraged cultivation of export crops and spread cocoa pods throughout the region (Koonar, 2014). The significant amount of labour that cocoa required was often done by young students at mission schools and later taken up by families. The paradoxical truth is that the low costs of production, resulting from free family labour, contributed to the entry of Ghana into the global cocoa industry, where it remains one of the biggest producers nowadays (Berlan, 2013).

The type and nature of tasks in cocoa production represent another driver of child labour. Cocoa farming activities include land clearing, harvesting, opening cocoa pods with machetes and carrying the beans to the drying mats (Busquet *et al.*, 2021). The line between 'acceptable' and 'unacceptable' work for children is defined in national legislation (Amoo, 2016), but not always easy to draw in practice. Commonly agreed upon criteria exist: some cocoa farming activities, such as using sharp tools, spraying agrochemicals or working at night, can be harmful to children's health and development and are therefore considered hazardous work for children, and fall within the category of the worst forms of child labour (Luckstead *et al.*, 2022). Striking is that the proportion

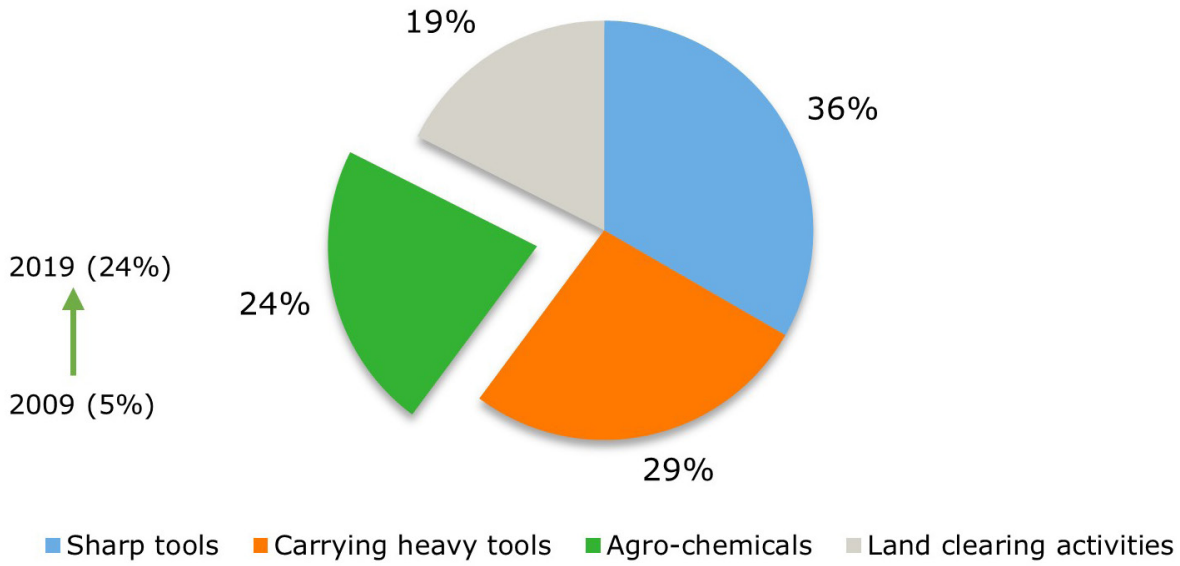
of children exposed to agrochemical products in Ghana and Côte d'Ivoire combined increased by almost 20 percent in the last decade, from five percent in 2009 to 24 percent in 2019 (Sadhu *et al.*, 2020). The numbers show that additional actions need to be taken to reduce the number of children engaged in hazardous work in the cocoa sector (see Figure 1).

Household poverty combined with labour-intensive cocoa farming and low financial returns are important factors in the re-occurrence of child labour.

Cocoa farming is still labour intensive due to a lack of mechanization and largely takes place at smallholder farms in rural regions, where adult labour is either not available or too expensive because cocoa farming yields too little financial rewards. This results in the widespread use of family labour on farms, which is in many cases the only available option left for households (Busquet *et al.*, 2021).

Moreover, some households live in such conditions of poverty that children need to work in order to meet the essential needs of the household or to pay for their own education. Cocoa farming is often the main income source for cocoa farming households, which makes them especially vulnerable to shocks related to cocoa production or price volatility. Generally, the cocoa price is below what is considered a reasonable living wage for farmers, which makes it an important concern to the occurrence of child labour. It is estimated that around 70 percent of cocoa farmers in Côte d'Ivoire and Ghana do not earn a living income (van Vliet *et al.*, 2021). In the end, parents often have no choice but to engage their children in farm work: cocoa incomes are insufficient to support the family and there is often a lack of social protection systems to fall back on in case of income or other shocks (Gatsinzi and Hilson, 2022).

Figure 1. Share of children in Ghana and Côte d'Ivoire in 2018-2019, by type of hazardous work



Source: **Sadhu, S., Kysia, K., Onyango, L., Zinnes, C., Lord, S., Monnard, A., and Rojas Arellano, I.** 2020. Assessing Progress in Reducing Child Labor in Cocoa Production in Cocoa Growing Areas of Côte d'Ivoire and Ghana. NORC at the University of Chicago. https://www.norc.org/PDFs/Cocoa%20Report/NORC%202020%20**Cocoa%20Report_English.pdf.**

Social norms, access to free and quality education and the lack of decent employment opportunities all play a role in the persisting incidence of child labour in cocoa growing households. In sub-Saharan Africa, poverty and the absence of social protection services are widespread, which means children are key to making ends meet before present needs and future uncertainties. In addition, the engagement of children in labour can also be seen as a form of 'informal apprenticeship training', which will secure a better future for them (Abdullah *et al.*, 2022). This may be explained by the widespread youth unemployment and lack of rural employment opportunities in general, which makes the agricultural sector attractive and the school system unappealing. Education itself is free in Ghana, but matters such as school uniforms, textbooks or transportation to schools need to be paid for by the household (Adonteng-Kissi, 2018). In addition, in some rural communities, schools are difficult to reach by walking and the quality of schools can be poor.

Migrant children, especially those unaccompanied, are particularly exposed to the risk of being engaged in hazardous work, forced labour and child trafficking, and thus require special attention. There were around 14 000 children in forced labour in Ghana between 2013 and 2017 (de Buhr and Gordon, 2018). The majority of these children are young boys who leave their region of origin when they are around 13 or older and come from the northern regions of the country, or even Burkina Faso and other surrounding countries including Côte d'Ivoire, Togo and Mali. They arrive in the southern regions during periods without agricultural activity in the North, to sell their labour in the South (Massart, 2012). Solutions to protect these children should go beyond the cocoa farm, and should address the lack of access to resources in the country or region of origin, which is an important driver for child migration (Busquet *et al.*, 2021). Many people in rural areas still lack basic services such as clean water, sanitation, health care and social protection. In Ghana, only 52 percent of the rural households have continuous access to safe drinking water, and a third (32.9 percent) of all rural households lack toilet facilities (compared to only 7.4 percent in urban households). The situation is more severe in the rural Savannah areas, where 72.6 percent of households have no toilet facilities. Lastly, around 22 percent of rural households in Ghana reported not having access to medicine or medical treatment in 2015 (Ofori-Mensah, 2017).

2.2 Current monitoring systems and initiatives

This section takes a closer look at existing child labour monitoring systems, initiatives, and the stakeholders involved. The purposes of the activities outlined in this section vary from monitoring child labour prevalence to pricing or traceability of the cocoa bean. Any innovative technology would ideally build on these existing initiatives to be able to make processes more efficient and useful for local and national stakeholders.

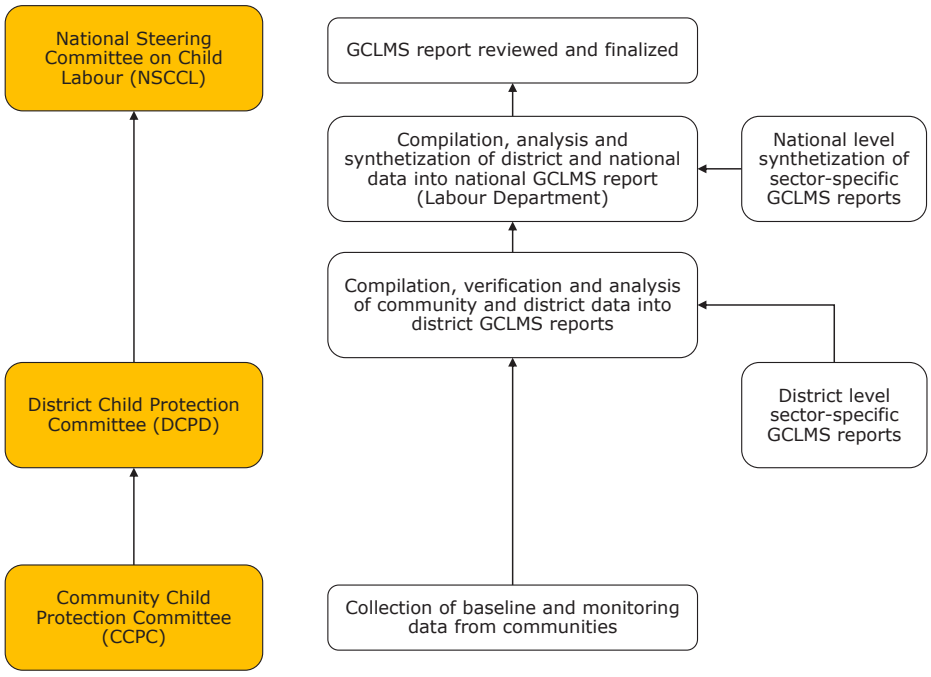
The Ghana Child Labour Monitoring Systems (GCLMS) is the government of Ghana's national child labour monitoring system and originated from the harmonization of four previous systems. These monitoring systems were set up by the Labour Department of the Ministry of Employment and Social Welfare (MESW) in various sectors and districts between 2001–2009, covering around 17 000 children. The first system mainly consisted of a tracking database focused on former children in child labour situations identified via questionnaires (Ministry of Employment and Social Welfare, 2010). The data was collected by Non-Governmental Organizations (NGOs) as part of the ILO-IPEC Ghana Country Programme (GCP). The second system (2003) focused on cocoa and rice (Ministry of Employment and Social Welfare, 2010). It was run by a hierarchical administrative system of Child Labour Committees (CLCs) from the community through the district to the national level. The third system was an integrated child labour monitoring system which ran between 2006–2009, and the fourth, a community child labour monitoring system (CCLMS) was set up in 2008, and conceptualized under the National Programme on the Elimination of Child Labour in Cocoa, focusing on the cocoa sector. This latter continues to be implemented (2017–2021), and is a collaboration between the Ghana Cocoa Board, the Child Labour Unit under the Ministry of Employment and Labour Relations; the Department of Social Welfare (a State Agency under the Ministry of Gender, Children and Social Protection), the Anti Human Trafficking Unit (AHTU) of the Ghana Police Service, and the Ghana Education Service under the Ministry of Education.

The Ghana Child Labour Monitoring System is meant to be a holistic and dynamic process for eliminating the Worst Forms of Child Labour. Ideally, the system involves repeated and continuous monitoring by direct observation of workplaces, schools, and training centres to track boys and girls to ensure their school attendance. After the identification of children in child labour and a determination of the risks they are exposed to, appropriate referral takes place to the relevant services. Part of this system is verifying that children have been removed from child labour and are tracked to make sure they have ended up in satisfactory alternatives. According to the Government of Ghana, every child labour intervention should use GCLMS as the basis for the identification, assessment, referral and monitoring of children in (suspected) child labour. The Labour Department serves as the depository of child labour data, and works with an online database with access to reports, statistics and information on children in child labour situations and children at risk (Labour Department, 2022). The GCLMS works with committees at three levels (see Figure 2). The Community Child Protection Committees (CCPCs) can deal with a child labour case immediately when it is identified, but should also report the cases to the district level, which reports every six months to the national level. The national level releases an annual progress report. When children in child labour situations or children at risk are identified, they are mainly referred to the Department of Social Welfare for remediation efforts.

It is unclear what the exact coverage of CCPCs is overall. Based on information provided by the stakeholders consulted, some communities are still in the process of setting up CCPCs, and some CCPCs are in place, but not active.

The Government of Ghana has recently invested in the piloting of Child Labour Free Zones in which the Child Labour Monitoring System plays a crucial role. A Child Labour Free Zone (CLFZ) is an integrated area-based approach where eliminating child labour is mainstreamed into wider governmental and non-governmental poverty alleviation strategies. Various interventions aim at prevention, removal, rehabilitation and reintegration of children found in child labour situations into education and are combined with reaching out to those at risk; empowering local actors and improving families' livelihoods; delivering services to children and families; and possibly making a well-defined geographical or administrative area 'child labour free'. According to the Government of Ghana, 'child labour free' does not mean that there is no incidence of child labour in the area, but rather demonstrates that the area has an effective mechanism to address and remediate child labour cases at the community level (Labour Department, n.d.). In Ghana, for a zone to be declared free of child labour, it needs to adhere to a set of conditions at the community and district level, such as the existence of a Community Child Protection Committee (CCPC), workplace monitoring, a school inspection system and the availability of social services like parental counselling and economic empowerment services. There are currently 36 indicators against which those conditions can be checked.

Figure 2. Visualization of data collection and reporting levels under GCLMS



Source: Labour Department. n.d.. *Introduction to the Ghana Child Labour Monitoring System.* Powerpoint Presentation.

The presence of a Child Labour Monitoring System is one of the requirements for an area to be declared a CLFZ. In 2020, the Ministry of Employment and Labour Relations – which is responsible for the implementation of CLFZs – piloted the CLFZ guidelines in the Ashanti Region and Western North Region in Ghana together with the Japanese International Cooperation Agency (JICA) and the Japanese NGO Action Against Child Labour (ACE). The recommendations of the pilot report stress the importance of minimizing the operational costs of complex data systems and the harmonization and consistency between monitoring activities to avoid duplication (JICA and ACE, 2022).

Today, many companies implement child labour monitoring and remediation systems, targeting around 590 000 households in Côte d'Ivoire and Ghana in 2021 (ICI, 2021a). The International Cocoa Initiative (ICI) developed its own monitoring system for its private sector members: the Child Labour Monitoring and Remediation System (CLMRS, see Annex 1). Some private companies implement CLMRS through ICI, others have their own independent programmes. These systems share several key characteristics, in line with the CLMRS benchmarks, including awareness raising in communities, actively identifying cases, providing support to children identified in and at risk of child labour, and follow-up to determine further needs and measure impact. Monitoring takes place through child interviews during household and farm visits. The CLMRS system is often embedded in company supply chains in order to identify, address, and prevent child labour. ICI's evaluation of the impact of their CLMRS shows that 34 percent of children found in child labour are no longer in child labour after two consecutive follow-up visits (ICI, 2021a), stating that it is important for at least two follow-up visits to take place as some children are likely to engage in child labour again. This is reiterated in the evaluation of the CLRMS implemented by Nestlé, stating that of the children identified in child labour, 29 percent was not doing hazardous tasks at the last two visits, 41 percent was not doing hazardous tasks at one of the two visits, and 31 percent was still doing hazardous tasks (Nestlé, 2019). The latter group of children is especially worrying.

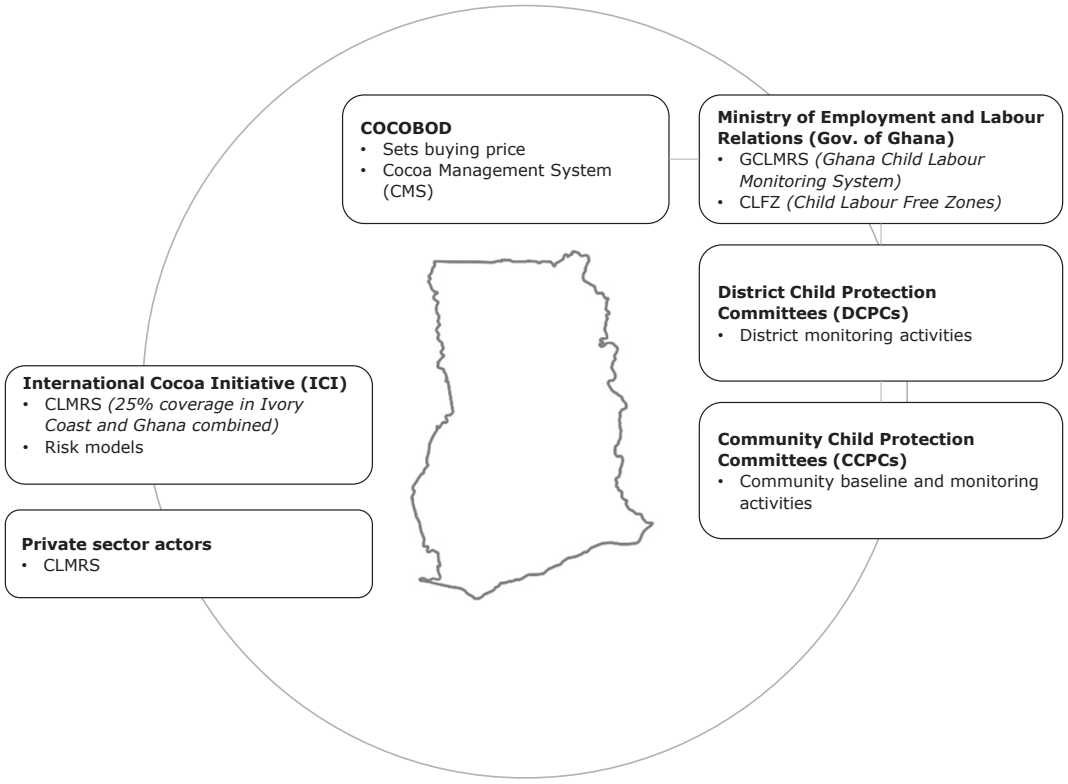
ICI developed and implemented a risk model in the context of a CLMRS innovation pilot in Ghana. ICI recently developed a risk model for estimating the risk of child labour at the household level. The aim of this model is to better understand which households mainly need to be visited and require remediation support. The model was developed to avoid unnecessary costs by focusing mainly on the households with the highest risks. As the basis for this risk model, they use ten indicators (based on the data set of the NORC report (Sadhu *et al.*, 2020)) related to farming, cocoa volume, revenues of the previous year, and household characteristics. This dataset was used to calibrate the child labour risk model and a pilot was executed in 2019 (Foubert, 2021). The aim of this pilot was to test the feasibility of using a readily available farmer registry to predict the risk of child labour, which would then make it possible to prioritize high-risk households for monitoring visits under a

CLMRS. The pilot revealed that individual characteristics, such as the child's sex and age, systematically improved the model's accuracy (Foubert, 2021). Overall, the risk model was concluded to be over 90 percent reliable. Another risk-based model was developed by ICI for Tony Chocolonely and tested in Côte d'Ivoire. The model was designed to identify additional children at risk of hazardous child labour, to ensure that no case of hazardous child labour would be missed and to prevent more vulnerable children from falling into child labour. Two datasets were used for the model: 1) a subset of the NORC dataset; and 2) data from Tony's Chocolonely's CLMRS. The models used up to 12 variables to predict each child's hazardous work for children status (Foubert, 2021). See Annex 2 for the variables used in both risk models.

The Ghana Cocoa Board (COCOBOD) is developing a database with the ultimate aim to ensure full cocoa traceability.

COCOBOD is the Ghanaian government-controlled institution that focuses on production, research, extension, marketing and quality control of cocoa, including setting the buying price for cocoa in Ghana. The institution is solely responsible for Ghana's cocoa industry, controlling the purchase, marketing and export of all cocoa beans produced in the country. It operates through her five subsidiary companies to achieve her mandate. Currently, COCOBOD is developing a Cocoa Management System (CMS), based on socio-economic data that is collected on cocoa households and their communities. The CMS will consist of a database of all cocoa farmers in Ghana and all cocoa transactions. The intention is to make transactions visible in real time, ensuring the traceability of

Figure 3. Summary of stakeholders and monitoring activities in Ghana



Source: authors' own elaboration.

cocoa throughout the chain (IDH, 2020). The system is meant to adhere to the new European Union due diligence standards, requiring full traceability along the cocoa value chain. For the traceability dimension of the ongoing European Union regulations, companies would have to send a compliance report, including GPS coordinates of location of origin of the referenced commodity. Although there is little public information available on the system, one source indicates that in preparation of the roll-out, around 1 000 farmers' data was collected and issued with Ļocoa Ŧdentification Ļards (CIC) (Chan, 2020). A next step is said to be to cover the entire cocoa farming industry, comprising of close to 700 000 farms. At the time of writing, Ghana's Deputy Minister for Food and Agriculture indicated the CMS to be 'almost completed' (Dapaah, 2022).

2.3 Takeaways and challenges in child labour monitoring

Based on the overview and learnings of current monitoring systems and initiatives and key stakeholder consultations on the root causes and monitoring of child labour in Ghana's cocoa sector, two main takeaways and several challenges arise that are key to take into account in proposing innovative technologies in child labour monitoring systems. The two main takeaways related to current monitoring practices are:

Speaking to household members and children directly and understanding the household context is the most accurate way to identify children at risk of or in child labour. Although automated and standardized data collection systems may provide the most cost-effective way of monitoring child labour, several stakeholders stressed the importance of household and farm monitoring visits to adequately assess the risk of child labour in each household context. This allows for a rich understanding of the household situation and direct contact with the children at risk. This is crucial to be able to offer the needed support and refer and remediate a child labour case.

An Integrated Area-based Approach seems important to deal with child labour holistically. The basis of the CLFZ approach is that it goes beyond the cocoa sector only, as was the case in previous monitoring systems. Child labour prevalence is highest in the agricultural sector, which comprises more than just cocoa production. An integrated approach encompasses the broader range of root causes of child labour and ensures that child labour does not simply shift from one sector to the other.

Apart from these takeaways, there are five key challenges that novel technologies have the potential to address:

Challenge 1 Costs: current monitoring systems are costly and challenging to scale up. Household and farm monitoring visits are important and provide the level of detail necessary to truly estimate the risk of child labour. However, systems such as GCLMS and CLMRS are complex and costly, which makes them challenging to

scale up. Data collection and the training of data agents require resources that would ideally be spent on remediation activities. Facilitating the ease and integration of monitoring activities should ideally free up resources for remediation. Possibilities for integrating data collection activities, for example in the national census, are currently underutilized.

Challenge 2 Coverage: the majority of cocoa-growing households in Ghana and Côte d'Ivoire combined are currently not covered by a child labour monitoring system. Linked to the cost associated with current monitoring systems and the challenge to scale up, is that only a minority of households are covered. Moreover, many cocoa-growing households live in rural contexts with isolated villages that are difficult to access. The lack of coverage is on the agenda for industry and other stakeholders, reflected by ICI and its members' pledge to cover 100 percent of the cocoa supply chain by 2025 (ICI, 2021c).

Challenge 3 Timing: monitoring through direct observation is time- and resource consuming. Monitoring of child labour is mainly done via direct observation, through household and farm visits. The intended frequency of monitoring visits varies from once every two years to three times a year. These monitoring visits are resource intensive because they are time-consuming, but also give space to subjectivity. For example, ICI found that agents are more likely to identify child labour cases if they are female, have secondary or higher level of education, and have more experience (ICI, 2021b).

Challenge 4 Data sharing and integration: there is limited data and information sharing across monitoring practices. Despite the many monitoring systems, risk models and pilots, there is no central database where information is collected, shared and validated. The comparability of results across CLMRS projects is compromised as different projects work with different data collection tools (ICI, 2021b). The Government of Ghana now intends to set up a national database to see who is working in which area, but this is currently still in pilot status. Moreover, there is limited traceability of activities: governments are not always aware who is conducting which activities where.

Challenge 5 Digital exclusion: the absence of digital infrastructure and digital illiteracy affects poor smallholder farmers. Cocoa regions are characterized by poverty, remoteness, and the rainforest agroecological zone particular conditions; low population density, low infrastructure coverage (transportation network, electric grid), and biophysical challenges to cellular coverage. From an economic perspective, these are not targeted areas for service providers to deliver good quality network coverage, and thus challenging to reach.

3. Exploring the potential application of blockchain in child labour monitoring

This chapter introduces blockchain technology as a potential application in child labour monitoring and highlights its features that could (partly) address the challenges related to current child labour monitoring systems.

3.1 Introduction to blockchain and its potential applications

Blockchain technology was introduced in 2009 (Nakomoto, 2009) and describes a new way of data handling. It refers to a specific form of distributed ledger architecture, which stores data and transactions in a list of blocks, which are linked cryptographically (Gakwaya *et al.*, 2018). This enables data collection and transactions between members of complex networks without the need for intermediaries, such as central authorities or banks. The idea behind this technology is that everyone has equal access, but no one is in control. Blockchain can provide new ways of economic and social governance if applied appropriately (Kewell *et al.*, 2017). In the cocoa sector, blockchain could and has been used to improve transparency, traceability, trust and consensus between the private sector and other actors in the chain, up to the consumer.[1] Blockchain is not a single technology, but rather a combination of technologies, together forming the building blocks of the blockchain (van Wassenaer *et al.*, 2021). The data in blockchain is 'chained' by referring every block of data to its previous block. Different from a traditional database, data are immutable after being created as a block in the blockchain.

A blockchain system can be designed in either public or private form. A well-known application of blockchain is that of the 'smart contract': a digital contract that is executed as soon as the conditions of the contract are met. Public blockchain networks are accessible to anyone and the data stored is visible to all participants - sensitive data can be encrypted to ensure privacy. Private blockchain networks do not allow access to data without permission: this is similar to databases used by large corporations (IFAD, 2019). A private blockchain is also referred to as permissioned, which means only authorized gatekeepers

[1] For an example of this application, see https://www.theother.bar/

can add information, as opposed to the second application as a public blockchain (permissionless) that allows many users to do so (Christ and Helliar, 2021).

The potential benefits of the use of blockchain in the cocoa value chain are numerous. The collection of data and transactions in blockchain can occur in real-time and are irreversible and immutable. It can also increase transparency of data related to finances, products and locations, leading to more trust between value chain actors. Ownership of assets and documents are also more easily exchangeable because they are represented in code (Deloitte, 2018; Petrutiu and Kruijssen, 2020). Blockchain is therefore attractive to companies, as it can reduce costs, streamline processes, as well as increase process speed (Hughes *et al.*, 2019). Due to its tamper-proof design, blockchain can also be used for digital claims of identity and ownership, for example in the case of land registration or education and birth certificates.
In agricultural supply chains, chain transparency provided by blockchain could incentivize value chain actors to adhere to due diligence standards (OECD, 2019). A study on supply chain transparency in the African cocoa industry identified important enablers for blockchain adoption, consisting of technical characteristics (smart contract, security, compatibility, complexity/ease of use) and product, range and participant transparency (tracking product components, product processes and sustainability information). The enablers can help in making elaborate investment decisions related to blockchain for sustainable supply chain transparency (Bai *et al.*, 2022).

However, despite its potential benefits, several limitations exist in blockchain systems, in part since most applications in agricultural chains are still in pilot stage. The most pronounced limitations are the lack of privacy in public blockchains, a lack of integration possibilities, a lack of reliable and functioning (digital) infrastructure (especially in an African context), and computational costs and energy consumption (Gakwaya *et al.*, 2018). Some public blockchains, such as bitcoin, require a significant amount of energy because of its proof-to-work consensus mechanism that dominates the blockchain's energy consumption with 66 TWh per year (Sarkodie *et al.*, 2022). Private blockchains have energy consumption patterns closer to centralized traditional information systems. Another key limitation related to reliable data collection is known as the oracle problem. In the example of the cocoa sector, data would have to be collected through stakeholders in the sector and beyond, such as government entities and farmer cooperatives. The reliability of these data is always a concern if they cannot be properly verified by a third source (Chainlink, 2020). Moreover, in the use of blockchain as a database, the key feature of immutability could be an issue for storing and altering data where necessary: information stored in the blocks cannot be changed. However, movements in existing databases (such as adding or removing data) could be registered in a blockchain system to ensure the validity of external databases (MongoDB, n.d.).

3.2 How blockchain has been applied in cocoa and child labour

Blockchain pilots have been used to improve transparency in the cocoa chain. Real-time tracking of products is one of the applications most used in the cocoa sector. Olam's Farmer Information System, for example, tracks farmers' products and allows farmers to check cocoa prices and participate in online trading. Money can also directly be paid into the farmer's mobile money wallet (Olam, n.d.). Tony's Chocolonely works with a 'Beantracker': beans can be traced real-time (Tony's Chocolonely, n.d.). The Beantracker was tested with a pilot blockchain system to see if the efforts could be scaled up (Tony's Chocolonely, 2018). However, they found that bringing field data into the 'digital world' was quite a challenge and that the training was too labour-intensive. The blockchain pilot was discontinued, but the Beantracker is still in use. Another example is cocoa product start-up Koa, which launched a blockchain-based programme in March 2022 that aims to improve the transparency of the cocoa supply chain and to ensure proper pay for Ghanaian farmers (Newar, 2022). The programme is supported by partnerships with German supply chain company Seedtrace and South African telecoms company MTN Group. Koa said it hopes to ''improve transparency and accountability'' by ending what it calls ''scandals and cocoa farmer poverty.'' Data about product movement and payments are collected and shared by MTN Group. The company inputs payment data onto Seedtrace's platform, which confirms the location and amount paid for the products at each waypoint on the supply chain. This system also capitalizes on Ghana's push to reduce theft attacks on farmers by mandating they be paid digitally rather than in cash. Through MTN, the record of farmers' digital payments is stored on the public blockchain.

JICA and Deloitte conducted a child labour blockchain pilot in Côte d'Ivoire and intend to test the system in Ghana. The use case was tested with technology from DLT Labs among a group of 50 farmers. This private blockchain system relied on the input of data from two sources: farmer group representatives and school teachers. Farmer group representatives were asked whether children had worked, in which tasks and for how long, while school teachers were asked to report school attendance and school opening times. If the data did not match, a monitoring team consisting of members of an NGO verified the information with the farmer group and the school through interviews. Fairness points were awarded according to the percentage of children who met the three conditions: 1) no child labour; 2) no hazardous labour; 3) accuracy of the data (percentage of accurate data) (JICA, 2022). During the pilot, they encountered several challenges. First is that the tablets used to input the data were provided to the farmers and schools, who did not always have a working internet connection: they had to move to a separate area to be able to enter the data. Second, the cost of the maintenance of the platform was high, as it needed to be operational 24/7. Last, the pilot system relied heavily on the input of reliable data that needed verification by a

third source: the oracle problem. Moreover, child labour was revealed in only three cases out of 2 366 applications, far lower than the national prevalence rates (JICA, 2022). This suggests reporting or selection bias during the pilot.

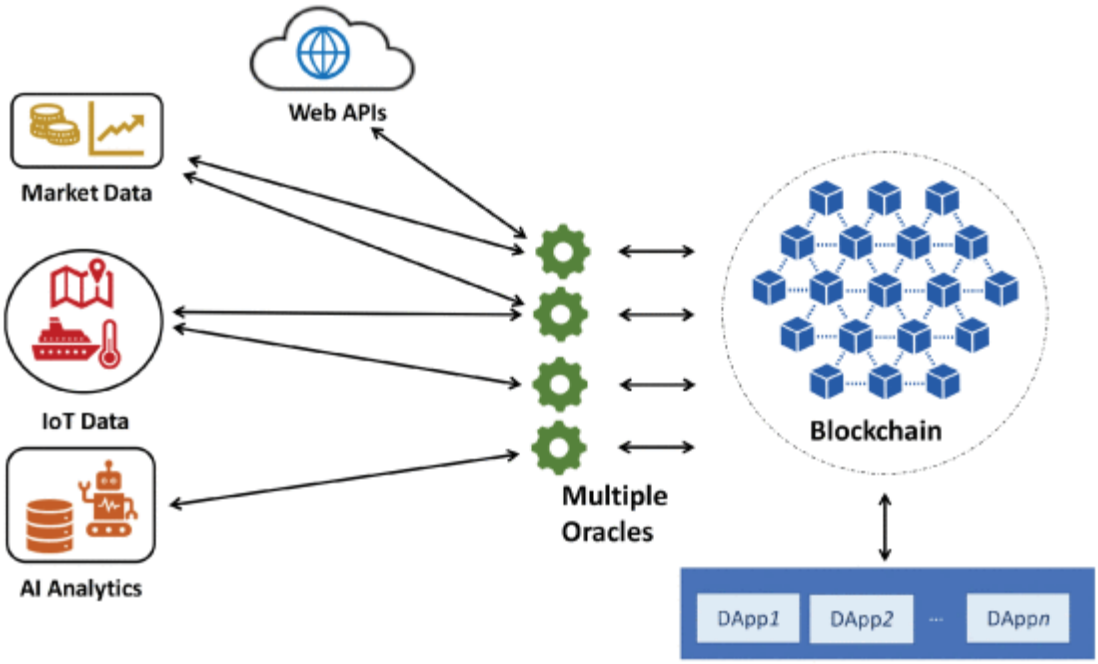
3.3 Preliminary design ideas and considerations

Blockchain-based solutions or blockchain applications can take various forms, depending on the design choices made across the three layers of any blockchain application (van Wassenaer *et al.*, 2021):

- The distributed ledger (including what is included in the data blocks, consensus algorithms and programming languages);
- The governance of the ledger (including who has which rights, management of the nodes and smart contract use);
- The ecosystem (the whole of actors and stakeholders involved in the blockchain application).

Blockchain is a good tool for registering data, but cannot solve data quality problems. Regarding the distributed ledger, Chapter 4 presents a proposed data framework through the notion of key data elements (KDE), the concept used in the context of blockchain when referring to information elements (Blaha and Katafono, 2020). This data framework is relevant in any digital scenario for child labour monitoring, not only in the application of blockchain. This proposed data framework is also referred to as common knowledge work in blockchain enabled supply chains. Blockchain is a great tool to register data, but cannot solve data quality problems: the

Figure 4. The role of oracles in blockchain ecosystems



Source: **al Breiki, H., al Qassem, L., Salah, K., Rehman, M. H. U., and Sevtinovic, D.** 2019. Decentralized access control for IoT data using blockchain and trusted oracles. *2019 IEEE International Conference on Industrial Internet ICII*, 248–257.

Table 1. Core actors in a blockchain for cocoa traceability

Actors	Description	Mapping to Figure 3 *(Summary of stakeholders and monitoring activities in Ghana)* – the actors mentioned here could possibly take up this role, to be further tested and articulated in a proof-of-concept project
	Cocoa value chain actors, being the farmer, buyer, exporter, retail or consumer.	Private sector actors (CLMRS)
	The *oracle*, inspired by its definition from the blockchain community (Al-Breiki *et al.*, 2019). The oracle pushes trustworthy information to the device, such as child labour occurrence risk.	• COCOBOD • Ministry of Employment and Labour Relations • District and Community Child Protection Committees
	The device with a mobile application that gives for example the farmer advisory and transactional services. The device could also be a desktop computer.	Private sector actors (CLMRS)
	The overarching data backbone here depicted as a blockchain. The data backbone registers KDE in the blockchain.	• International Cocoa Initiative (ICI) • COCOBOD

Source: authors' own elaboration.

success of the application will depend on the quality of the data input. Blockchain solutions are often based on technical assumptions that do not address problems such as information asymmetry and asynchrony (Powell *et al.*, 2021). The data framework initially started with the idea to have child labour risk data source as an oracle deployed (al-Breiki *et al.*, 2019). Oracles are trustworthy external data sources that can be used to feed data into the blockchain (see Figure 4).

Oracles can appear in many forms. The KDEs presented in Chapter 4 could be made available as an oracle service. The oracle can have an algorithm that 'calculates' a risk indication of child labour occurrence at any moment in time and place, using all the available KDEs, using a probabilistic approach.

To better understand the business case in action, the deployment in a production context is here articulated. See Table 1 for the core actors:

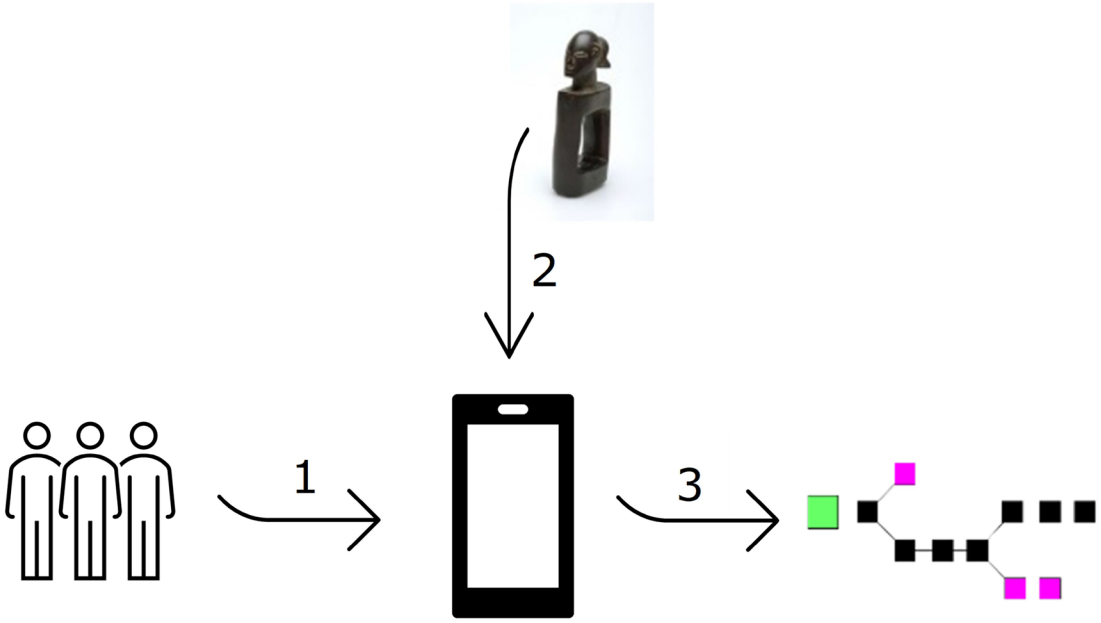
Figure 5 shows how this could work in a scenario where blockchain is integrated. The cocoa producer registers the selling of cocoa in data flow 1 through a mobile device. In data flow 2, the mobile device reaches out to the oracle and retrieves an indication from the oracle of the child labour risk at that moment in time and place. Data flow three illustrates that this information is stored in the blockchain. When the consumer buys the chocolate, the consumer could receive information through a QR code about the risk of child labour occurrence through a mobile device (through the reversed data flows 3 and 1).

The application of this conceptual model in practice could lead to the exclusion of cocoa producers in areas that are indicated as high child labour risk areas. Providing transparency to the consumer could mean that the consumer chooses not to buy that particular chocolate, in particular if other brands or products do not show this kind of transparency. This

could exacerbate the income conditions of the cocoa-growing households in that area. This conceptual model should therefore only be applied if the 'do no harm' principle can be guaranteed: not exposing cocoa-growing households to increased vulnerabilities that could lead to increased child labour rates. A possible solution is to present the information to consumers transparently, but in a way that to incentivizes them to buy more chocolate coming from that vulnerable cocoa-growing area, thereby making that purchase instrumental to the improvement of the living conditions of those cocoa farmers. The price premium could directly contribute to the farmer's income or to programmes that improve farming families' conditions. How this would work out in practice needs to be investigated further and therefore the conceptual model in Table 1 is not yet production ready.

Another potential solution to the risk of decreased consumer demand is to adapt the governance of the ledger to a private blockchain system. The management of the blockchain would be in the hands of a single, identifiable party that safeguards the information stored in the blockchain, controls the consensus mechanism and who and who does not have access to the blockchain. This could ensure that the information on child labour risk estimation is only available to certain stakeholders, such as industry partners (including ICI), CCPCs, DCPCs, COCOBOD, the Labour Department and the Department of Social Welfare. This would require a strong network of collaboration between all actors, a willingness to share information and agreement on the relevance and collection of the KDEs and the type of conclusions that are drawn from them. This information would allow this blockchain consortium to identify

Figure 5: Conceptual model with data flows



Source: authors' own elaboration.

relevant remediation measures tailored to the specific vulnerabilities of that specific cocoa-growing area.

There is potential for blockchain technology in child labour monitoring, but key considerations need to be addressed before application. Related to the five challenges discussed in Chapter 2, blockchain has a potential role to (partly) address these challenges:

Challenge 1 Costs: Household and farm monitoring visits and training of staff are costly. Blockchain could potentially have a role in mitigating these costs if all stakeholders can make use of the same key data indicators and collection tools. The other side of the costs is the financial upkeep of the system: the start-up costs of blockchain can be significant. A scaled up blockchain system across the value chain would require significant investments in training, provision of digital appliances, digital infrastructure and upkeep of the platform. Moreover, all stakeholders – from household level to national level – must be educated on the technology and the challenges it can address (Shang and Price, 2019). One part of these costs applies to digitalization in general (for example the costs for implementing data flow 1 in Figure 5). Data flow 2 (feeds from an oracle) is a policy decision and can also run without blockchain. Costs can be saved here to have stakeholders agreeing on a set of shared oracles, rather than using their proprietary oracles. The additional blockchain costs are for data flow 3, but can become a cost saver if the various stakeholders agree on reusing the same dataflow, rather than duplicating it.

Challenge 2 Coverage: Reliable data is one of the most common areas of concern of any blockchain system (Petrutiu and Kruijssen, 2020). Without high-quality data, it is difficult to guarantee the validity of a project. Therefore, a blockchain system cannot and should not replace household and farm monitoring visits, as household-level information is still key in identifying and remediating child labour cases. However, the technology could play a role in collecting data on communities that are not currently covered by these direct monitoring activities.

Challenge 3 Timing: The oracles in a blockchain system have the potential to identify areas that are at high risk of child labour, after which targeted monitoring visits could take place. In theory, this can reduce the time and resources spent on wider application of monitoring visits. However, it is important to reiterate that identifying areas at high or low risk of child labour does not reveal the risk for individual households. Areas indicated as low risk could still include households with children in child labour.

Challenge 4 Data sharing and integration: Setting up a blockchain system requires strong collaboration and consensus-building between stakeholders in the Ghanaian cocoa sector. Facilitating ease of data sharing between these stakeholders is a great benefit of a blockchain system. The risks for data flows 2 and 3 are the mutual dependencies between the various actors and related risks can be anticipated through clear service level agreements. Data flow 2 can be made redundant, to decrease dependencies.

Challenge 5 Digital exclusion: The application of a blockchain system could spur further digital development, by investing in the necessary digital infrastructure and the provision of appliances. The system also relies on digitalization, which means that in remote rural areas (where blockchain could make the most difference), the challenge of implementing these investments is greater. However, all three before mentioned data flows do not need a continuous stable internet connection, it is sufficient to synchronize the data at regular points in time.

4. Data framework for child labour monitoring in Ghana's cocoa sector

A well-functioning blockchain system relies on good quality data, on the basis of which choices can be made and actions can be taken. Data elements in such a system need to be available, reliable and relevant. This chapter presents a potential data framework with Key Data Elements (KDEs) that can be registered as Critical Tracking Events (CTEs) in a blockchain system. The first set of KDEs (1–10) were selected on the basis of FAO's inception mission to Ghana in 2019 and follow up discussions with several stakeholders, and verified for relevance by the stakeholders consulted for this paper. The second set of KDEs (11–14) arose during discussions between FAO and WUR and rely solely on Geographical Information Systems (GIS). The following two sections outline each KDE in detail, after which a summary of the potential of each KDE in a data framework is provided in the last section.

4.1 Potential KDEs to be monitored

After FAO's inception mission to Ghana in 2019 and follow up discussions with several stakeholders, ten KDEs were selected for potential contribution to a blockchain system. The KDEs are meant to estimate the child labour risk to which cocoa farming families in Ghana may be exposed to. These KDEs are:

- KDE 1: Cocoa farm gate price
- KDE 2: Poverty
- KDE 3: Food insecurity
- KDE 4: Distance to primary and lower secondary school
- KDE 5: Distance to water sources
- KDE 6: Birth registrations
- KDE 7: School dropout rates during the main cocoa harvest season
- KDE 8: Children's involvement in hazardous work
- KDE 9: Sex and age of children
- KDE 10: Community Child Protection Committees in place

To ascertain the value added of these KDEs, it is necessary to assess each one of them based on their availability, reliability and relevance for child labour in agriculture risk estimation and monitoring. This section present the main conclusions of this exercise.

Key Date Element 1: Cocoa farm gate price

The purchasing price for cocoa in Ghana is set by COCOBOD through the Producer Price Review Committee (PPRC). COCOBOD procures all its cocoa beans through about 41 Licensed Buying Companies (LBCs). The LBCs buy cocoa beans from producers in Ghana and sell them to COCOBOD (Ahoa *et al.*, 2020). The first KDE aims to trace the transaction between the LBCs and the cocoa farmers of the targeted area. At the moment of the transaction, the farm-gate price of the cocoa seeds could be recorded into the CLRM application and stored in the relative blockchain system. That way, it would be possible to monitor how the farm price varies over time and over consumer price fluctuations, impacting the purchasing power and poverty level of the cocoa farmers, thus their economic dependency on child labour. Besides estimating the income instability of cocoa farmers, such information could potentially inform remediation measures. For instance, while the idea behind fixed prices is to offer farmers a more stable income, evidence shows that higher prices lead to living incomes only for farmers with larger plots or those that are already relatively wealthy (Waarts and Kiewisch, 2021).

- *Availability*: The fixed farm-gate price is announced by the government through the Produce Price Review Committee at the start of the cocoa harvesting season in October and is maintained for the period of one year. For the 2022/2023 season, the farm-gate price was increased by 21 percent compared to the previous year.
- *Reliability*: COCOBOD sets the farm-gate price for cocoa once a year through a multi-stakeholder approach, once 60 to 70 percent of the predicted harvest of next year has been sold (Boysen *et al.*, 2023). Although this ensures price stability during this year, it also results in relatively lower farm-gate prices than in liberalized markets, also because the national board takes a high percentage. However, the farm-gate price can be considered a reliable data point.
- *Relevance*: This data would allow to estimate the price increase needed to bring those farmers above the Living Income Benchmark (latest figures suggest that the average cocoa household income in Ghana is more than 50 percent below the LIB), thus reducing their need to rely on child labour. This estimation can take advantage of previous research, suggesting that eliminating the worst forms of child labour would require a cocoa price premium of 2.81 percent and eliminating regular work (non-hazardous work but over the maximum hours allowed for a child) and the worst forms would require an 11.81 percent premium (Luckstead *et al.*, 2019). However, as a key data point for the risk of child labour, this indicator cannot narrow down risks across communities as the farmgate price is the same for everyone and would have to be combined with other data elements.

Key Data Element 2: Poverty

As discussed in Chapter 2, poverty is at the root of the high incidence of child labour in agriculture, including in cocoa-growing areas. The interconnection between poverty and child labour in agriculture is driven by the difficulty of low-income households in rural areas to meet their immediate basic needs and to achieve sustainable livelihoods, meaning there is no other way than to engage children to supplement or substitute adult labour. In many cases, children are pulled out of school to engage in agricultural labour, or their performance at school suffers. They are less likely to find decent work when they are older, less likely to adopt new practices and technologies and innovate if they remain in agriculture, and more prone to be trapped in poverty and suffer the long-term effects of the hazardous conditions they faced as children. This has a negative impact on communities and perpetuates a vicious cycle of poverty (FAO, 2020).

- *Availability*: Several available datasets could be used to measure KD2 on poverty.
    - The Asset Wealth Index[1] is a raster layer that uses publicly available sources to estimate household asset wealth. The Atlas AI group created a model using satellite imagery layers to produce an output to measure economic wellbeing in countries within Sub-Saharan Africa, including Ghana, and parts of South Asia. This model draws comparisons amongst all the countries included in the model, therefore the final output is produced in a normalized index. The main data sources used in the methodology include landcover from Landsat, SRTM digital elevation, Night-time lights, PALSAR imagery, the demographic and health surveys (DHS) program and global human settlement layer (GHSL), among others.
    - Ghana has recently joined several countries from across Africa in using an official Multidimensional Poverty Indicator (MPI) to track and measure poverty. The Ghana MPI tracks twelve indicators relating to three dimensions: Living Standards, Education and Health. The MPI is calculated in Ghana for ten different subnational regions (Mensah *et al.*, 2020).
    - The 'World Poverty Clock' provides real-time estimates until 2030 for almost every country in the world, among others, Ghana, and monitors progress against ending extreme poverty.[2]
    - The Ghana Statistical Service, conducts the Ghana Living Standard Survey every five years. This survey provides information for understanding and monitoring living conditions in Ghana (Ghana Statistical Service, 2019).

[1] For an example of this application, see https://www.theother.bar/

[2] https://worldpoverty.io/map

- *Reliability*: By providing household-level data in a 1-km resolution raster image for the years 2003-2021, the Asset Wealth Index is considered reliable. Similarly, data from the Ghana Living Standard Survey as well as the Annual Household Income and Expenditure Survey (Ghana Statistical Service, 2022) are both nationwide surveys which capture data at the household level, thereby proving to be reliable. Nonetheless, there are different ways of calculating poverty (Living Income Benchmark, World Bank Poverty line, etc.), and an agreed upon definition needs to be found by all stakeholders involved in a potential blockchain system.
- *Relevance*: With poverty being among the core drivers of child labour, KDE 2 lies among the most relevant ones. In addition, it is closely related to KDE 1 on cocoa farm gate price, as it determines the income security of cocoa farmers and their potential economic dependence on child labour.

Key Data Element 3: Food insecurity

Food security has a close link with poverty and child labour, because if parents cannot provide or buy sufficient food for their families, they may rely on children to engage in subsistence and income generating activities. The Comprehensive Food Security and Vulnerability Analysis (CFSVA, 2020) reports that only 16.9 percent of children aged 6 to 23 months met the minimum dietary diversity score in Ghana. This low dietary diversity has a link with the high food insecurity reported in the CFSVA 2020. Household food security is a key predictor of the dietary diversity score of school-aged children. Also, hungry children are more likely to be absent from school (Tamiru and Belachew, 2017).

As a proxy for food insecurity, the presence or absence of a school meal programme could be used to estimate child labour risk. Research shows that school feeding programmes lead to a decrease in child labour (Dago and Yogo, 2022). A child requires adequate complementary foods after six months for normal growth since at this age breast milk alone would no longer be sufficient to maintain the child's recommended daily allowances of nutritional requirements to enhance healthy growth and development. Poorly developed children are more likely to have low intelligence (cognitive ability), and therefore would have low interest in staying at school. In recognition of the role played by food in keeping children in school, the WFP supports the Government of Ghana with technical support for school feeding in Ghana. In 2006, WFP in collaboration with the government distributed food to 200 000 pupils in over 400 schools. The Ghana School Feeding Programme (GSFP), launched in 2005, serves as the basis for Ghana's social protection strategy, which encourages more children to attend school and have daily access to a meal (WFP, 2018). This was later transitioned to the government, who now implements school feeding in over 10000 schools in Ghana, with technical support from WFP (Dunaev and Corona, 2019).

- *Availability*: There are several available datasets that could be used for this KDE.

- The Statistics, Research and Information Directorate of the Ministry of Food and Agriculture (MOFA-SRID), in partnership with CILLSS, and other partners, conduct Cadre Harmonise (CH)[3] which leads to evidence generation on the number of food insecure populations within the country two times in a year. In addition, MOFA-SRID established a Food Security and Nutrition Monitoring System (FSNMS) which complements the data sources for the CH.
- The Ghana Statistical Service conducts Annual Household Income and Expenditure Survey every quarter. As part of this survey, household food insecurity information is collected, analysed and reported. This survey also collects data on labour statistics.
- The World Food Programme in collaboration with FAO, IFAD and the World Bank conducted a nationwide comprehensive food security and vulnerability analysis (CFSVA) in 2020 which collected and analysed data on the food security status of households in all 260 districts in Ghana.
- The Ministry of Finance in Ghana collects data on number of schools and pupils that benefit from the school feeding programme. The current reach is about 3.4 million children.

- *Reliability*: All food security data sources mentioned above can be considered reliable. However, nationwide food security data collection can be very costly. Therefore, the CFSVA is mostly conducted in five years intervals. The FSNMS data collection covers 120 out of the 260 districts in Ghana. It may need to be scaled up if data from all districts are to be considered. The data collected by the Ghana Statistical Service is nationally representative. It could be modified to collect statistics on child labour.
- *Relevance*: As mentioned above, food insecurity is a core driver of child labour in agriculture. In fact, child labour takes place in subsistence farming, to meet income and food ends. Hunger feeds another root cause of child labour: barriers to education. Food insecurity is reported to be associated with school absenteeism. It also affects the health and psychological well-being of students. A lesson learnt from the implementation of school feeding in Ghana is that hungry students pay less attention in class. School attendance is found to be highest in schools with school feeding than schools without school feeding. Tamiru and Belachew (2017) reported that food insecurity has a significant association with poor school attendance (Tamiru and Belachew, 2017). Consistently tracking the food security status of households

[3] CH process is coordinated by the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS) and jointly managed by the Economic Community of West African States (ECOWAS) and Union Economic Monetaire West Africa (UEMOA) within the Sahel and West African sub-region.

and the presence of school feeding programmes could help get an indication that children are not hungry and would stay in school.

Key Data Element 4: Distance to primary and lower secondary school

The long distances from households to schools or even the absence of schools constitute a barrier to children's access to education. This exposes them to a higher risk of remaining out of school and engaging in child labour. This is particularly true during the harvest season, when it is more likely that children are required to help the family on the farm. In a study done by (Porter and Blaufuss, 2002) on children and transport in southern Ghana it was found that the maximum distance walked to school was usually around 3-4 kms from satellite settlements in the village area to a maximum of six kms for off-road villages. KDE3 could allow to trace and record the distance from the targeted farming community to the nearest primary or lower secondary school, in line with Ghana's upper age for compulsory schooling: 14. This model would require that data of all primary schools are available and georeferenced and that cocoa trees are identifiable on satellite imagery, before being inserted into the blockchain system.

- *Availability*: The locations of schools can be collected through the National Schools Inspectorate Authority, which has the mandate to license schools in Ghana. According to the Education Regulatory Bodies Act 2020, every school in Ghana is required to have an official license to operate (National Schools Inspectorate Authority, n.d.). Another useful source is of data on school location is UNICEF's School Mapping, which uses high-resolution satellite imagery and applies Deep Learning techniques to map every school in the

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Table 2. Findings from Ghana in the NORC report

	2008-2009	2018-2019
School attendance	89 percent	96 percent
Prevalence rate of child labour in cocoa production	44 percent	55 percent

Source: **Sadhu, S., Kysia, K., Onyango, L., Zinnes, C., Lord, S., Monnard, A., and Rojas Arellano, I.** 2020. *Assessing Progress in Reducing Child Labor in Cocoa Production in Cocoa Growing Areas of Côte d'Ivoire and Ghana.* NORC at the University of Chicago. https://www.norc.org/PDFs/Cocoa%20Report/NORC%202020%20Cocoa%20Report_English.pdf.

world.[4] As of now it locates schools in several countries, including Ghana. This mapping tool collects data from Ghana Educational Service, Ghana Library Authority, Ghana Statistical Service, Bluetown, ITU and Meta Ericsson.

- *Reliability*: Because the Education Regulatory Bodies Act 2020 is relatively new, it is not known how many schools operate unlicensed. This would mean that direct observation is necessary to determine school buildings that are operational. This could be complemented by GIS data, for example UNICEF's School Mapping. A possible shortcoming is that the tool shows schools' ability to connect to the internet, and not the distance from certain locations, which would need to be estimated. Moreover, not all schools may be operational. Satellite images would need to be refined by in-person controls on the functioning of the school facilities mapped. A further improvement of the reliability of this model would be to filter out those farmers without children eligible for primary or secondary school (Maduako *et al.*, 2022). Lastly, as child labour impacts children's education also in terms of performance and learning (see evidence from Côte d'Ivoire (Bhattacharya *et al.*, 2021), it is worth flagging that the quality of education cannot be assessed through GIS.

- *Relevance*: From the NORC report (Sadhu *et al.*, 2020) we have learned that most children in Ghanaian cocoa growing households go to primary school (see Table 2). School attendance rates have gone up in the last ten years, while child labour prevalence has also gone up. Nonetheless, studies do suggest that the longer the distance to school, the more difficult it is to reconcile school and work (Vuri, 2008). Research shows that children in cocoa-growing areas also combine work and schooling and also work over the weekend, which could also have an impact on school performance (Understanding Children's Work, 2017). Other evidence suggests that the presence of a primary school in the community is associated with a lower rate of child labour, by eight percent in Ghana (ICI, 2019a).

[4] https://projectconnect.unicef.org/map/country/gh

Key Data Element 5: Distance to water source

Water collection is important for human consumption and for agricultural purposes, such as watering animals and small garden plots. In some cases, the distances to water sources are such that children (mostly girls) need to travel over an hour to fetch water. This increases the risk of staying home and out of school (FAO, 2020a). Given this nexus between water management and child labour in agriculture, KDE4 aims to feed the blockchain system with data on the distance between the cocoa farming area and water sources or fetching points, as a driver of a higher or lower risk of children being exposed to child labour in cocoa-growing areas. Although the distance to water source can be an important determinant of child labour, the concern should also be in the weight of the water that is being carried by the child combined with the age of the child.

- *Availability*: UNICEF is collecting yearly data on drinking water, sanitation and hygiene in schools by country. In addition, there is an interactive dashboard[5] that shows trends in drinking water service levels, rural and urban service levels and percentage of the population that lack basic sanitation per country. However, rural communities where the incidence of child labour is higher often rely on surface water sources like hand-dug wells, ponds, dugouts, and other sources that are difficult to determine without direct observation (Gyau-Boakye, 2009), in particular when it comes to the physical distance between them and households in rural areas.
- *Reliability*: Surface water sources will need to be verified through direct observation or ground level data, also to determine whether they are operational and used. GIS techniques could be used as complementary sources, measuring the distance between identified water sources and communities.
- *Relevance*: Stakeholders agree that the distance to a water source is an important data element. To further increase its relevance, water sources could also be tracked based on their distance to schools. According to the NORC report, water sources at school and other infrastructural improvements on school grounds help children to focus on their classes, which improves the quality of school time (Sadhu *et al.*, 2020).

Key Data Element 6: Birth registrations

Birth registrations are an important prerequisite for many basic human rights, which means the lack of birth registrations can mean an increased risk of child labour. Without legal proof of identity, children may miss out on essential government programs like education, child protection and health care. Moreover, birth certificates help protect migrant and

[5] https://washdata.org/data/household#!/gha

refugee children from separation from their families (UNICEF, 2020). In Ghana, birth registrations have increased to around 70 percent, although more people in urban areas register their children in the first year of their birth than in rural areas (UNICEF, n.d.). Still, the latest estimates show that 30 percent (more than 300 000) of children born every year are not registered, and progress has stalled (UNICEF, 2013).

- *Availability*: The Births and Deaths Registry (BDR) is responsible for registering all births and deaths in Ghana. Although estimates can be made about the number of children without birth certificates, the exact number and location of unregistered children is unknown. Estimates of the number of unregistered children can be made in rural and remote areas by using other sources, such as the Population and Housing Census. Another source of information is Save the Children's platform on children's inequalities, which displays mapping on birth registration in several countries, including Ghana. [6]

- *Reliability*: Formal registration in registries and censuses is considered reliable. As for Save the Children's platform on children's inequalities, figures collected are only displayed at regional level, which limits the data relevance and localized remediation measures.

- *Relevance*: Feeding the blockchain system with KDE5-related information would still be relevant in light of UNICEF latest estimates. Nevertheless, the barriers to obtaining a birth registration in Ghana are low, and it is possible to obtain it later in life. Moreover, the figures collected by Save the Children's platform on children's inequalities are only displayed at regional level, which limits the data relevance and localized remediation measures.

Key Data Element 7: School dropout rates during the main cocoa harvest season

School attendance rates may diminish during the main cocoa harvest season, from October to March, as children are requested to help their families on the cocoa farm. Children dropping out of school to work in cocoa plantations is considered, especially when below the minimum legal working age, child labour. Monitoring school attendance and how it varies during the main cocoa harvesting season may provide a good indicator on the child labour risk to which families in cocoa-growing areas are exposed to.

- *Availability*: This KDE would need to be tracked through direct observation, which could be done be either a focal point identified in the reference school (i.e. a headmaster), or a former teacher now part of a Community or District Child Protection Committee. The experiences from the JICA and Deloitte pilot (see Chapter 2) in Côte d'Ivoire could be used for the set-up

[6] https://www.savethechildren.net/grid

of the system. Schools would need to be provided with digital appliances to collect the data.

- *Reliability*: For reliability purposes, this KDE would need to be verified by another source. In the Côte d'Ivoire pilot by JICA and Deloitte, teacher entered data was compared to data sourced from farmers themselves and compared. A similar system could be set up, which would require households to be supplied with digital appliances too. This would offset the benefit of a monitoring system with the absence of direct observation.
- *Relevance*: According to the NORC report, the proportion of children reporting that cocoa work was interfering with schooling increased significantly in Ghana from seven percent in 2008-2009 to 20 percent in 2018-2019 (Sadhu *et al.*, 2020). The increasing numbers are concerning and indicate that interference is becoming a larger issue. This KDE could be expanded to cover the whole year, instead of only cocoa harvest seasons.

Key Data Element 8: Children's involvement in hazardous work

As indicated by Figure 1, 24 percent of all children engaged in hazardous child labour in Ghana's cocoa sector are exposed to harmful pesticides, 29 percent carry heavy loads and 36 percent use sharp tools. Overall, children's involvement in hazardous child labour increased from 5 to 24 percent from 2009 to 2019. As it lies among the worst forms of child labour, addressing children's engagement in hazardous tasks is a matter of priority. To that end, improving the monitoring of this KDE could be instrumental to refine the estimation of child labour risk to which Ghana's cocoa farmers are, even involuntarily, exposed to.

Pesticides exposure represents a peculiar case. Because of insect pest control programmes (Ninsin and Adu-Acheampong, 2017), increasing land degradation (World Bank, 2017) and increase of cocoa production in general (Kolavalli and Vigneri, 2011), the use of agro-chemical products by cocoa growing households increased significantly over the past years in Ghana. Household-level agro-chemical use is highly correlated with children's exposure to pesticides. In fact, children's exposure to agrochemicals increased from 7 to 32 percent in Ghana between 2008-2009 and 2018-2019 (Sadhu *et al.*, 2020). Pesticide poisoning is especially harmful to children, because their body, brain and nervous systems are at critical stages of development. Because they are in a development stage, children have fewer natural defences and can develop serious health problems as a result of pesticide exposure (FAO, 2021). For example, children have larger pores and can, therefore, absorb more chemicals into their bodies; their organs are also still developing, making exposure to toxins potentially more dangerous. For both biological and behavioural reasons, children are typically more vulnerable than adults to risks associated with pesticides.

- *Availability*: Data on children's involvement in hazardous work at local level, including pesticide exposure, is currently not collected. A possible practice to explore is for this KDE to be

collected and registered in a blockchain system by two community's focal points: a member of the Community or District Child Protection Committee (CPCs) and a representative from the Community-based Health Planning and Services (CHPS) Compound present in the area. The former would undertake a pre-screening in the community, while the latter would record the children hospitalized following work-related accidents. However, a possible limitation is that hospitalized children are likely to be a minor share of children victims work-related incidents. Both focal points would be trained on how to identify children's direct and indirect exposure to hazardous work, recognizing acute and chronic adverse health effects. In those communities or districts where no CPCs nor CHPs are present, data availability would be limited. Concerning pesticides, monitoring efforts could be supported by the Rotterdam Convention, whose Secretariat is part of FAO, and that provides support worldwide upon request and has experience in identifying high-risk scenarios, for example by administrating surveys on farm level on cases of pesticide use that could lead to severe effects for children.

- *Reliability*: CPCs and CHPs are considered as reliable sources of information. To ensure data reliability and quality, events related to children's exposure to hazardous work could be subject to verification from both sources, in addition to regular labour inspections.
- *Relevance*: This KDE is of high relevance, as children's engagement in hazardous work lies among the worst forms of child labour, and it shall be addressed as a matter of priority. Moreover, the integration of a preventive component could further enhance the KDE's relevance. In fact, the data collection undertaken by the community leader could be accompanied by awareness raising across the farming community on how to prevent children's exposure to dangers in farm settings. These activities could adopt a Participatory Learning Appraisal approach and tailored trainings, such as body mapping exercises to sensitize on the impact of harmful pesticides.

Key Data Element 9: Sex and age of children

In ICI's risk model, sex and age were found to be the most powerful predictors of hazardous child labour (Foubert, 2021). Overall, the risk of child labour increases with age, as older children are more likely to conduct hazardous tasks. The share of boys involved in child labour and hazardous child labour in cocoa production is higher than girls: 58 percent for boys versus 42 percent for girls in Ghana in 2018-2019 (Sadhu *et al.*, 2020).

- *Availability*: Basic demographic data such as sex and age of children can be collected through government records or farmer registration data from national or company traceability systems. The requirement for this is that children are registered at birth. Although the awareness of the necessity to register your child at birth is high in Ghana (see KDE5), the unavailability

of birth registration services in some areas means that parents are unable to register their children (UNICEF, 2013).

- *Reliability*: Once formally registered, data on sex and age of children can be considered reliable.
- *Relevance*: Sex and age-disaggregated data is highly relevant to understand the main specificities and root causes of child labour in a given context, and formulating tailored prevention and remediation measures. On the one hand, gender aspects and distribution of tasks in agriculture or within the household are key determinants of why, how and under what conditions children engage in labour. For instance, water fetching is more often assigned to girls. Besides, also the consequences of child labour are highly gendered, leading to the reproduction of gender discrimination patterns in agriculture (FAO, 2020). On the other hand, age-disaggregated data allows for identifying the age-inappropriate tasks in which children may be involved. For example, while a 13-year-old Ghanaian child can be exposed to long working areas hindering her or his education, a 17-year-old child could be involved in carrying heavy loads. Understanding these potential risks may inform preventive and remediation measures.

Key Data Element 10: Community Child Protection Committees in place

Community Child Protection Committees (CPCCs) are an important remediation source: they advocate for the protection of children, respond to cases of child labour or refer cases to authorities. Committee members may include representatives of police services, traditional authorities, health services, CSOs and religious leaders. The absence of a CCPC in a cocoa-growing area or community could indicate an increased risk of child labour.

- *Availability*: The Child Labour Unit (CLU) of the Ministry of Employment has this information available.
- *Reliability*: Although the CCPCs in place can be verified through the CLU, the existence of a CCPC may not provide sufficient information on its functioning and effectiveness. This would need to be verified through another source, for example referral and reporting rates provided by the Ministry of Employment.
- *Relevance*: CPCCs undertake different functions, including but not limited to ensuring that children's rights are respected, and that they live in an environment free from abuse, violence, neglect and exploitation through case management and integrated social services (AMA, 2021). That said, the absence or active presence of CPCCs in a given cocoa-growing area may be a relevant indicator contributing to a higher or lower risk exposure to child labour situations.

4.2 Potential KDEs to be monitored through GIS

The main bottleneck for including the abovementioned KDEs in a blockchain is that data is not readily available and would still need to be collected or verified through direct observation. Direct observation remains the most accurate, yet time and resource consuming, data collection method. Therefore the KDEs are more difficult to operationalize in a fully digitalized and cost-efficient system. Second, the KDEs assessed so far provide a picture of a given situation, estimating the current exposure to child labour risk in a given cocoa-growing area. However, they may have less forecasting capacity, representing an obstacle to the preventive capacity of data collected through direct observation. A potential solution to these challenges is to integrate in the monitoring model - and ideally in the blockchain system - selected data collected through GIS tools, such as satellites.

As this paper targets cocoa value chains, the first key data to identify to support such model are cocoa-growing areas at a granular level. Nonetheless, GIS classification methods for detecting cocoa farms are still being evaluated. To date, only rainforest agro-ecological zone data and 10km resolution global production layer are available (IFPRI MapSPAM). Satellite imagery crop type classification is not commonly used for tree crops, as cocoa and forest spectral information are quite similar. There is still research to be conducted to understand the difference and refine a classification algorithm to test with RS data (Sentinel-2 and SARS data). While further

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research on the above would be of great utility to the development of a blockchain system for the cocoa sector, we can already assess what other KDEs could be detected and monitored through GIS to assess the child labour risk exposure faced by cocoa farmers. The majority of these relate to climate change-related events, which exacerbate some of the key root causes of child labour in agriculture, such as poverty, hunger and livelihoods disruption.

Climate change threatens global food security and the ability of countries to eradicate poverty and achieve sustainable development. Although the nexus between climate change and child labour in agriculture is yet to be fully explored, there is wide evidence of the impact of climate change-related events on poverty and food insecurity, particularly in rural areas. Climate change disproportionally affects rural populations in the poorest countries that rely on natural resources and are subject to changing rainfall patterns, unpredictable weather events, sudden natural disasters, etc. (FAO, 2020). In particular, climate- and environment-related disasters have detrimental impacts on children and young people, especially in rural and marginalized communities. According to Terre des Hommes, environmental causes do have an impact on whether children work and the type of work they do (Terre des Hommes, 2017). Occurrences of droughts, soil depletion or heavy rainfall is likely to increase, exacerbating households' vulnerabilities and their exposure to dependency on child labour. In the same vein, environmental degradation leads to droughts, floods, failing crops and soil erosion, resulting in higher food prices, food insecurity, strained natural resources, economic vulnerabilities and potential migration (FAO, 2020).

Several climate change-related events are already being monitored by currently active geospatial systems. This makes multi-temporal and quasi-real-time satellite imagery and geospatial data on environmental trends already available. A relevant example is FAO's Hand in Hand Geospatial platform,[7] an open-access source providing advanced information, including climate change, food security indicators and agricultural statistics, for more targeted agriculture interventions. The data are sourced from FAO and other leading public data providers across the UN and NGOs, academia, private sector and space agencies, including key FAO flagship databases. Another useful source is the IPCC Interactive Atlas,[8] a novel tool for flexible spatial and temporal analyses of much of the observed and projected climate change information. Lastly, Earth Map[9] is a free and open-source tool developed by the FAO in the framework of the FAO - Google partnership. It was created to support countries, research institutes, farmers and members of the public with internet access to monitor their land in an easy, integrated and multi-temporal manner. It

7 https://www.fao.org/hih-geospatial-platform/en/

8 https://interactive-atlas.ipcc.ch/

9 https://earthmap.org/login

allows visualization and analysis of satellite imagery and global datasets on climate, vegetation, fires, biodiversity, geo-social and other topics. Through this software, average temperatures and rainfall can be measured to estimate the vulnerabilities of cocoa-growing areas.

By seizing the above-listed and other GIS instruments, the most relevant climate change-related KDEs for Ghana's cocoa sector could be integrated into the child labour estimation model and potentially incorporated into the blockchain system. These KDEs would feed the child labour risk estimation by providing information on the current and projected exposure of cocoa farmers to climate change-related events, and therefore to the risk of being or becoming functionally or economically dependent on child labour.

Climate change KDEs collected through GIS could contribute to real time child labour risk estimation. Contrary to the previous KDEs described, climate change KDEs could contribute to chid labour risk estimation through real-time and forecasted data with a high degree of availability and reliability, as they are secondary data that are not entered directly by a person or entity.[10] Moreover, as many households are not covered by any monitoring system, these secondary data could provide an early warning indication of risk for those areas that are not covered by current child labour monitoring systems.

This section assesses the following KDEs through GIS:

- KDE11: Droughts
- KDE12: High temperature
- KDE13: Precipitations
- KDE14: Infrastructure

Key Data Element 11: Droughts

According to Cocoa Life, the evolution of local weather patterns such as droughts, exacerbated by deforestation, is preventing farmers to grow the needed cocoa. Some reports show that in the next 30 years, current cocoa-growing areas may no longer be suitable for cocoa production (Läderach *et al.*, 2013). The resulting loss in livelihoods and migration may expose children to a higher risk of being involved in child labour activities. Integrating droughts-related data into a blockchain system could contribute to the current estimation of the child labour risk to which cocoa farmers are exposed. Geospatial and satellite data may provide information on ongoing drought trends in cocoa-growing areas, improving the geographical accuracy remediation measures supporting cocoa farmers' resilience.

- *Availability*: There are several datasets indicating the magnitude and frequency of droughts in a given country. One of these is the Agricultural Stress Index

[10] It is important to reiterate that the best way to determine the occurrence of child labour is speaking to household members and children directly and knowing the household context. These KDEs may contribute to an estimation of risk to facilitate rapid and effective monitoring for the households at highest risk, but cannot replace household monitoring and remediation efforts.

System (ASIS) developed by FAO for early warning and monitoring of agricultural droughts. ASIS uses satellite-based data to detect agricultural areas with a high likelihood of water stress. Another available dataset is the Climate - Aridity Index (P ECMWF Land / PET MODIS) displayed by Earth Map. Through this index, UNEP defines drylands by calculating the ratio between average annual precipitation and potential evapotranspiration. Drylands are lands with an AI of less than 0.65. Drylands are further divided, on the basis of AI, into hyper-arid lands (AI <0.05), arid lands (0.05≤ AI <0.2), semi-arid lands (0.2≤ AI <0.5) and dry sub-humid lands (0.5≤ AI <0.65). The Aridity Index (AI) is calculated for the years 2001 to 2020 using the total precipitation product derived from ERA5-Land data from the European Centre for Medium-Range Weather Forecasts (ECMWF) and the potential evapotranspiration product derived from MOD16A2 MODIS/Terra Net Evapotranspiration 8-Day L4 Global 500m version six image collection. A second useful data source is the IPCC Interactive Atlas,[11] which shows regional trends of consecutive dry days at the regional level, including with some forecasting capacity based on different scenarios of temperature increase.

- *Reliability*: The datasets mentioned above are three out of several geospatial platforms providing valuable information on climate-related events, including droughts. They are commonly recognized as reliable source of information.
- *Relevance*: Cocoa farmers' related exposure to droughts is highly relevant when estimating their current and potential exposure to the risk of relying to child labour in agriculture. As mentioned before, drought-driven impacts on the quantity and quality of cocoa production may harm the livelihoods of farmers and their families, making them more dependent on the work of their children.

Key Data Element 12: High temperatures

The occurrence and impact of high temperatures are closely related to droughts. In fact, increasing temperatures impacts the evapotranspiration potential and the variability of rainfall patterns. The temperature threshold is set by literature. In general terms, temperatures above 32°C might affect plant growth. Based on the FAO Climate Smart Agriculture Sourcebook, extremely high temperatures above 30°C can do permanent physical damage to plants and, when they exceed 37°C, can even damage seeds during storage. The type of damage depends on the temperature, its persistence, and the rapidity of its increase or plants' capacity to adjust. It also depends on the species and the stage of plant development.

In addition to the impact on cocoa plant productivity and quality, high temperatures

[11] https://interactive-atlas.ipcc.ch/

create ideal environments for the proliferation of pests. In a close link with KDE8 on hazardous work for children, an increase in pest presence is leading farmers to increasingly use hazardous pesticides. As we know, children's exposure to hazardous pesticides (even indirectly) lies among the worst forms of child labour. In the case of high temperatures, climate models showcase not only showcase current data, but are able to forecast projected temperature increases. This could help estimate both the present and forecasted risk of cocoa farmers to see their livelihoods hindered, and their consequent potential dependence on child labour as a coping strategy.

- *Availability*: The near real-time and forecasted temperature increase could be monitored by looking at the number of days with temperatures higher than 32°C. The ''Climate - Days with Temp. > 32° threshold - Heat Stress (ECMWF Max daily temp)'' dataset on Earth Map shows the number of heat-stress days (defaults to temp > 32°C, this threshold can be changed in the legend) for a single year (use the legend time-button to change the year). The data comes from ECMWF ERA5 Land hourly reanalysis dataset that is reduced to daily maximums.
- *Reliability*: Likewise for droughts, data on temperature levels are drawn by credited and reliable datasets and GIS platforms. The Earth Map is one of these.
- *Relevance*: As higher temperatures may increase the water requirements of cocoa cultivation while decreasing crop productivity, their impact on cocoa production may exacerbate the vulnerabilities of those farmers and families whose income is already insecure, and who may rely on the work of their children as a coping strategy.

Key data element 13: Precipitations

The same climate models providing information on KDE11 and KDE12 project continues changes in the spatial and temporal distribution of precipitation patterns. In a self-feeding vicious cycle of deforestation, temperature increase, lower barriers to pests and droughts, a lower frequency and a higher intensity of precipitations can jeopardize the vitality of the cocoa plant and the livelihoods of the farmer who makes a living out of cocoa production. This is why precipitation represents the third climate change-related event worth monitoring to improve the estimation of child labour risk across cocoa-growing areas. Once again, GIS represents a valuable tool in this sense. Geospatial platforms can provide figures on current and projected precipitation levels, hinting at the climate-related risks to which cocoa farmers may be or will be exposed to, and the consequent impact on their livelihoods.

- *Availability*: The 'Precipitation Anomaly Forecast (Global - Month - 100 km)' in the HiH platform provides a 6-month forecasting of monthly precipitation anomalies. The dataset's source is the North American Multi-Model Ensemble. Furthermore, an alternative source of satellite data is Earth Map, which shows the number of days with rains above the

threshold of > 50 mm. This threshold can be changed as extreme rain events can differ greatly by geography. The dataset used is ECMWF ERA5 Land hourly reanalysis dataset that is reduced to daily maximums. Lastly, the IPCC Interactive Atlas provides the past, present and future Total Precipitation Trend Change at regional level.

- *Reliability*: The above-mentioned climate models are reliable data sources. Nevertheless, the level of local accuracy differs. The dataset used and shown by Earth Map provides particularly accurate local-level data, which could be highly relevant when it comes to targeting and monitoring specific cocoa-growing areas.
- *Relevance*: Similarly to KDE11 and 12, the current and forecasted level of precipitation may contribute to enriching the child labour risk estimation to which cocoa farmers are exposed, given their pre-existing vulnerability to climate change-related events. At the same time, such an indication can inform remediation measures related to the enhancement of farmers' resilience to climate change and environmental degradation.

Key Data Element 14: Infrastructure

Infrastructure investments are vital for improving basic needs in rural communities. Adequate infrastructure services, such as paved roads, internet and electricity connectivity, can improve living conditions and enhance connectivity for remote communities to other communities, villages or schools. For cocoa farming households, paved roads can make a significant difference in the cost and physical demand of moving produce from the farm to the market, as well as make it easier for children to access schools.

Although it is difficult to determine the direct link between infrastructure and the incidence of child labour, it is likely that when living conditions improve and household and farm tasks become easier to perform, the burden on children reduces

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(Leissle, 2020). Electricity access has been proven to be negatively correlated with child labour prevalence, which would not make it a good predictor of child labour risk (ICI, 2019b). Other KDEs also relate to infrastructure, such as the KDEs on distance to schools and water sources and relevant institutions such as CCPCs in place. This KDE could be complementary in providing information on the ease of mobility.

- *Availability*: The World Bank has developed a Global Infrastructure Map.[12] The map, which is updated every year, brings together all available global geospatial data layers relevant to infrastructure on a single platform. The map includes data on physical geography (including climate risk), human geography, economic geography, digital networks & services, energy networks & services, and transport. However, internet and energy data is not available for Ghana on the platform. FAO's Hand-in-Hand initiative works with an Accessibility analysis, which assess travel time and cost to major cities. The Ghana accessibility analysis was one the pilot cases that used network infrastructure (primary roads, railways) and other geographical elements (lakes and navigable rivers) to calculate the accessibility of urban and non-urban areas. The Hand in Hand initiative uses the World Mobile Broadband Coverage as well. The dataset displays the accessibility of cellular internet in a 1km resolution raster, thereby contributing to assess the connectivity of communities and services.
- *Reliability*: Paved road connectivity data is reliable, although the quality of the roads is more difficult to determine and needs direct observation. This is the limitation in general of GIS data: they represent generalizations of complex reality and should therefore be combined with data with a higher level of granularity.
- *Relevance*: As mentioned before, a direct link between child labour and infrastructure is difficult to establish, but it can be theorized that improved infrastructure may provide enhanced access to services for rural families, offering them educational, livelihood and market opportunities that may reduce their exposure to child labour dependency. However, more research is needed to confirm this.

4.3 Towards a KDE framework for estimating child labour risk

Several Key Data Elements were assessed against availability, reliability and relevance, resulting in different degrees of applicability to a possible child labour monitoring system through digital methods. This section gives a short summary of each KDE discussed.

[12] https://maps.worldbank.org/toolkit

- **KDE 1 on cocoa farm gate price.** This KDE would allow monitoring of price variation and estimate the price increase needed to bring those farmers above the Living Income Benchmark, thus reducing their need to rely on child labour. Nonetheless, the indicator cannot narrow down risks across communities, as the farm gate price is the same for everyone. It would therefore need to be combined with other data elements.
- **KDE 2 on poverty.** Poverty is one of the core drivers of child labour in agriculture, with several reliable datasets measuring it. To optimize the child labour risk estimation, it is recommended to opt for those indexes, such as the Asset Wealth Index, providing as much granularity as possible in their resolution raster images on household-level data. Most of all, stakeholders need to agree on an acceptable definition and measurement of poverty.
- **KDE 3 on food insecurity.** The availability and relevance of this KDE makes it a risk factor worth considering. At the same time, the main limitation concerns the high cost and time interval needed to collect household food insecurity information.
- **KDE 4 on the distance to school.** While this risk factor is conceptually highly relevant to assess child labour risk, current data collection systems present limitations. It is difficult to map unlicensed and informal education facilities, as well as those schools that are not operational or lack quality and relevance.
- **KDE 5 on the distance to water sources.** This KDE needs to be determined mainly through direct observation, with GIS techniques as complementary sources measuring the distance between water sources and households and between water sources and schools.
- **KDE 6 on birth registrations.** Despite the conceptual relevance of this risk factor, barriers to obtaining a birth registration are low in Ghana. Moreover, the exact number and location of unregistered children is difficult to obtain and the figures collected by existing mapping datasets are only displayed at the regional level, which limits the data relevance and localized remediation measures.
- **KDE 7 on school dropout rates during the main cocoa harvest season.** Trends on children reporting that cocoa work is interfering with schooling underline the relevance of this risk factor. However, to ensure data quality, the data collection system would require data verification from at least one source and the potential provision of digital tools to farmers.
- **KDE 8 on children's involvement in hazardous work.** Highly relevant in determining children's exposure to child labour, the indicator would need multiple verifications from key local actors to ensure data quality. This reporting should address the different hazardous tasks, including the use of sharp tools, carrying heavy loads and pesticide exposure. Regarding the latter, data collectors should be trained on how to identify children's direct and indirect exposure to hazardous work, recognizing acute and chronic adverse health effects.

- **KDE 9 on sex and age of children.** This indicator requires birth registration and is highly relevant to understand the main specificities and root causes of child labour in a given context, and formulating gender-sensitive and age-appropriate prevention and remediation measures. Although overall birth registration is relatively high in Ghana, a possible limitation is the unavailability of birth registration services in remote rural areas.
- **KDE 10 on Community Child Protection Committees (CPCCs) in place.** The absence or active presence of CPCCs in a given cocoa-growing area may be a relevant indicator contributing to higher or lower risk exposure to child labour situations. The Child Labour Unit (CLU) of the Ministry of Employment collects the information on the number and location of CPCCs.
- **KDE 11 on droughts.** There are several satellite-based datasets monitoring agricultural droughts with the potential for early warning. They represent valuable sources of information for estimating farmers' exposure to droughts-induced vulnerability, potentially leading to child labour dependence.
- **KDE 12 on high temperatures.** As higher temperatures may increase the water requirements of cocoa cultivation while decreasing crop productivity, this may exacerbate the vulnerabilities of cocoa farmers, who may rely on the work of their children as a coping strategy. As for droughts, data on temperature levels are drawn by credited and reliable datasets and GIS platforms.
- **KDE 13 on precipitations.** The current and forecasted level of precipitation may contribute to enriching the child labour risk estimation to which cocoa farmers are exposed, given their pre-existing vulnerability to climate change-related events. At the same time, the level of accuracy between the climate models examined differs. Preference should be given to datasets providing higher granularity.
- **KDE 14 on infrastructure.** More research is needed to determine the direct link between infrastructure and the incidence of child labour. For cocoa farming households, paved roads might make a significant difference in the cost and physical demand of moving produce from the farm to the market, as well as make it easier for children to access schools. Datasets on infrastructure exist, but they represent a generalization of a complex reality that needs to be combined with data with a higher level of complexity and granularity.

Last, a blockchain system based on the above KDEs would benefit from the identification of cocoa-growing areas at a granular level. Today's GIS classification methods only detect rainforest agroecological zone data, and not yet cocoa farms as cocoa and forest spectral information are quite similar. Further research to understand that difference and refine a classification algorithm for a high resolution cocoa mapping would be of great utility for the region's cocoa value chain and for the development of a blockchain system for the cocoa sector.

5. Conclusions

Child labour in the Ghanaian cocoa sector has long been a concern for industry partners, government and international organisations. Since signing the Harkin-Engel Protocol in 2001, increasing efforts have been made to eliminate child labour from the cocoa supply chain, including the upscaling of monitoring activities and effective remediation for child labour cases. This has resulted in a range of activities, including industry- and government-led Child Labour Monitoring and Remediation systems and implementation of Child Labour Free Zones. Despite these efforts, child labour remains present in the cocoa supply chain and has increased over the last decade (Sadhu *et al.*, 2020). Moreover, existing monitoring systems suffer from a number of key challenges, related to high costs, lack of full coverage of all cocoa-growing areas, the lack of real-time information, lack of data sharing across initiatives and a lack of digitalization.

This paper explored the potential application of blockchain to address part of these challenges and presented a data framework based on FAO's 2019 inception mission to Ghana in which this topic was discussed with stakeholders. With regards to blockchain, the exploration found promising results for its application in child labour monitoring, namely the potential to combine direct data collection with GIS and thereby make risk estimation mappings of areas not currently covered by CLMRS efforts. This way, blockchain and GIS could represent innovative digital tools serving as a backbone for data capture, validation, management and sharing information.

Beyond the assessment of the KDEs investigated, there are a number of important considerations on the blockchain system itself that would need to be addressed prior to a possible pilot:

- *Transparency*: A blockchain system should avoid a demand-driven exacerbation of cocoa farmers' vulnerabilities. Consumers may decide not to buy chocolate products associated with a higher risk of child labour, hindering their market access and aggravating their income insecurity. On the contrary, the information transparently presented to consumers should incentivize them to buy more chocolate coming from that vulnerable cocoa-growing areas, perhaps by making that purchase instrumental to the improvement of the living conditions of those cocoa farmers, such as by introducing a price premium. There are also ethical considerations regarding sensitive household data that should be taken into account when designing a public blockchain.
- *Costs*: The costs of starting up and maintaining a blockchain system should be considered, including its wider

digital infrastructure (apps and oracles) needed. Resources would be needed to strengthen mobile phone dissemination and broadband connectivity points in remote cocoa-growing areas.

- *Data quality*: Speaking to household members and children directly and knowing the household context is the most accurate way to assess the risk of child labour, meaning that risk mappings should not replace household monitoring visits, but rather complement them by improving risk estimation via real-time and forecasted KDEs monitoring. Data processing, analysis and interoperability between stakeholders also needs to be considered.
- *Complementing rather than duplicating:* The stakeholder field in the cocoa sector is scattered. If a blockchain application is to be successful, efforts should focus on building stakeholder trust and collaborations to arrive at a consensus mechanism for the use of blockchain.

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- *Energy consumption*: There are public blockchains that require a significant amount of energy, such as bitcoin, because of its energy intense proof-to-work consensus mechanism. Therefore, energy conservation measures must address the proof-of-work consensus mechanism by, for example, identifying alternative consensus mechanisms.

The data framework presented in this paper can be used to inform the design of a blockchain system or other monitoring systems. The identified KDEs rely partly on GIS techniques, as part of geospatial platforms. The related disciplines (GIS and data science) are valuable to further develop for child labour monitoring because of its methodological and potential cost advantages, as well as the possibility to cover areas currently not covered by monitoring systems. The introduction or piloting of the blockchain system explored in this paper would require the prior development of a solid data model with clear layering, weighting, scoring and validation of the selected KDEs, allowing to generate the child labour risk estimation.

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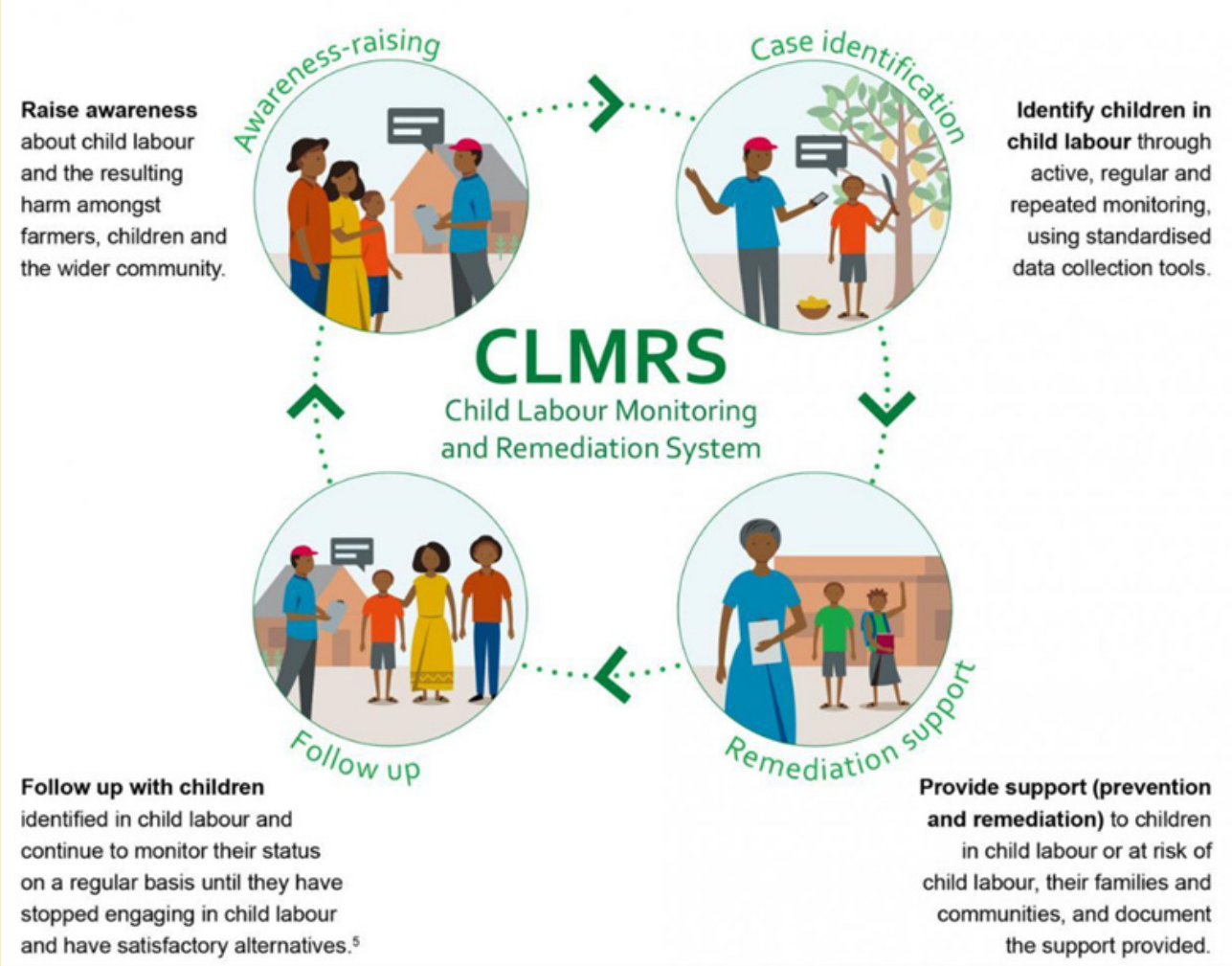
Annex 1 CLMRS explained

Overview of the Child Labour Monitoring and Remediation System as implemented by the International Cocoa Initiative.[1]



[1] https://www.cocoainitiative.org/our-work/operational-support/child-labour-monitoring-and-remediation-systems

Annex 2 Risk models

Indicators in the risk models used by ICI and Tony Chocolonely (Foubert, 2021).

Level	Variables	Risk model Ghana	Risk model Tony Chocolonely
Community	# of schools schools within 5 km		x
	access to electricity		x
	Access to improved drinking water source		x
	Presence of a primary health centre		x
Farm	Productivity	x	
	Size	x	
	# of sharecroppers on the cocoa farm		x
	# of cocoa crops under cultivation in the farm		x
Household	Literacy	x	
	Income	x	
	# of children	x	x
	Age children	x	
	Gender children		
	# of children under 5 in household		x
	# of children out of schol, in primary and in lower secondary		x
	# of male and female children in household		x
	# of adults in household		x

Annex 3 Additional blockchain use cases

The following list of additional resources and pilots were consulted as inspirational use cases:

- **Da Costa Guimarães, R., van Andel, M., Gocsik, E., and J. Brouwers** (2019). A chain of possibilities: Scoping the potential of blockchain technology for agri-food production chains in low- and middle-income countries. Fairfood and Wageningen University & Research. 190515_fairfood-report_chain-of-possibilities.pdf (knowledge4food.net)
- **Moyee Coffee** (https://www.moyeecoffee.com/?lang=en) using FairChain technology (https://fairchain.org/)
- **United Nations** (2020). Blockchain applications in the United Nations system: towards a state of readiness. Report of the Joint Inspection Unit. Geneva, 2020. https://www.unjiu.org/sites/www.unjiu.org/files/jiu_rep_2020_7_english.pdf
- **Food and Agriculture Organization of the United Nations** (2020). Blockchain application in seafood value chains. FAO Fisheries and Aquaculture Circular No. 1207. https://www.fao.org/3/ca8751en/CA8751EN.pdf
- **Senou, R. B., Dégila, J., Adjobo, E. C., and Djossou, A. P. M.** (2019). Blockchain for child labour decrease in cocoa production in West and Central Africa. IFAC-PapersOnLine, 52(13), 2710-2715. https://www.sciencedirect.com/science/article/pii/S2405896319316052
- **Wageningen University & Research** (2016-2022) project on blockchain applications for the mango and avocado chains. https://www.wur.nl/en/project/improved-mango-and-avocado-chain-helps-small-farmers-in-haiti-1.htm
- **Fairfood** (n.d.): Small farmer, big data. https://fairfood.org/app/uploads/2020/06/Small-Farmer-Big-Data-CTA-Fairfood.pdf

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