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Rule of Law 2.0: Blockchain Technology and the Development of Legal Institutions in Africa

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Abstract

The blockchain technology – or more generally, the technology of distributed ledgers (DLT) – has been heralded as a 'game changer' for the development of African economies. Whilst the focus of the discussion is usually on private sector applications, most notably including digital currencies such as 'Bitcoin', blockchain technology could also be used to improve the administration of public services and to strengthen the rule of law. With a view to the latter, this paper outlines the opportunities of DLT for developing nations in particular and offers an analysis of the most pressing legal and factual challenges that African governments need to resolve. The objective is to illustrate solutions which may be suitable for African jurisdictions in particular, hopefully assisting governments across the continent in developing their own tailor-made approach.

I. Introduction

In February 2018, the government of Kenya appointed an expert task force of eleven members from academia and industry to study the benefits and challenges associated with the technology of distributed ledgers and artificial intelligence (AI).[1] From a policy perspective, the project was considered as a kind of catalyst for the country's 'Big Four Agenda', namely the flagship project of President *Uhuru Kenyatta* to improve the nation's manufac-

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1 R. Odhiambo, 'Kenya Launches Blockchain and Artificial Intelligence Taskforce', 1 March 2018 (<https://bitcoinafrica.io/2018/03/01/kenyablockchain-and-artificial-intelligence-taskforce>).

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turing sector, food security, universal healthcare, and affordable housing.[2] Less than one and a half years on, the government taskforce (hereinafter: 'DLT Taskforce') solemnly presented its final report, stressing that 'emerging technologies can support and develop all of the Big Four Agenda points,' and that 'none have the potential to be as disruptive and transformative' as 'the Blockchain' and AI.[3]

As a matter of fact, the blockchain technology – or more generally, the technology of distributed ledgers (DLT) – has attracted the attention of a broader public as the database underlying Bitcoin, i.e. as the platform on which this so-called 'cryptocurrency' is created, stored and circulated among its users. With the Bitcoin price skyrocketing to more than 16,000 Euros in December 2017, both the currency itself and the technology supporting it have been praised as the heralds of a 'Fourth Industrial Revolution', stressing their disruptive impact on many sectors of the world's economy.[4] Although the Bitcoin craze seems to have subsided to some extent as of late 2019, the debate on the potential of DLT is far from over, contemplating a multitude of use cases for developing countries in particular. Aside from virtual currencies which I have analysed in an earlier article,[5] prominent use cases include a growing number of civic services such as digital land registries, the administration of development aid, or electronic voting facilities that prevent election fraud. More to the point, it seems that the blockchain technology might evolve as a 'game changer' for the development of legal institutions, for which the Kenyan example may be nothing short of paradigmatic.

Against this backdrop, this paper offers a general overview of the promises and opportunities of DLT in Africa, focusing on the development of legal institutions in the public sector in particular. For this purpose, I will first provide a very brief overview of the distinctive technological features (*infra*, section II.) which will serve as the basis for a closer examination of the respective use cases (section III.), but also of a number of challenges that African lawmakers need to address (section IV.). All things considered, I am going to argue that the widespread enthusiasm for DLT and blockchain is certainly justified in principle, but warrants critical reflection in detail. In the closing section (section V.), I will conclude with some final recommendations and an outlook.

2 See the Kenyan Government's Website at <https://big4.delivery.go.ke>; <https://vision2030.go.ke/towards-2030>; J. Keya, '4 Pillars Uhuru Announced in His Jamhuri Day Speech', 21 August 2018 (<https://www.kenyans.co.ke/news/25512-4-pillars-uhuru-announced-his-jamhuri-day-speech>).

3 DLT Taskforce, *Emerging Digital Technologies for Kenya: Exploration and Analysis*, Report of July 2019 (<http://www.ict.go.ke/blockchain.pdf>), 109.

4 E.g. P. Boucher, 'How blockchain technology could change our lives', *European Parliament Research Service*, February 2017 (<https://dx.doi.org/10.2861/926645>); D.L. Kuo Chuen, 'Fintech Tsunami: Blockchain as the Driver of the Fourth Industrial Revolution', 6 July 2017 (<https://ssrn.com/abstract=2998093>).

5 See A. Wilhelm, 'Blockchain Technology and the Development of African Economies: Promises, Opportunities, and the Legal Issues at Stake', 22(1) *Recht in Afrika* (RiA) 3-42 (2019) (<https://doi.org/10.5771/2363-6270-2019-1>), at p. 10-13, 20-24.

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II. A Brief Presentation of the Technology

1. DLT and Blockchain: A Technology of Trust

To illustrate the concept of distributed ledgers, it is helpful to first consider the features of their traditional counterparts, the so-called 'centralized ledgers'. In a centralized ledger, which can be likened to a classical business journal or a checkbook, data is essentially processed and maintained by a trusted administrator acting on behalf of certain external participants.[6] For example, this concept underpins the traditional land or commercial registries administered by a government agency, but also certain private databases such as the accounting systems of a bank or a stock exchange.[7]

A distributed ledger, by contrast, is a storage system that operates *without* any central administrator. Instead of relying on a single database, it is basically a digital register that is shared (or 'distributed') in a network of autonomous participants, each of which holds a constantly updated copy of the relevant data on his or her computer.[8] The data in question can potentially be of any kind, including a participant's personal information, a record of his or her tangible or intangible assets, or transactions on a specific market.

Although there are different types of distributed ledgers, the most important is certainly the Blockchain. As its name suggests, a blockchain is a distributed ledger in which a specific type of data is set out and built up in a sequence of successive 'blocks'. Each of these blocks contains a small piece of information known as 'hash' which can be likened to a digital fingerprint and connects its data with the content of the following block, thereby creating a chain of data in chronological order.[9] Owing to the absence of a centralized authority, adding new data always depends on some form of consensus between the participants, the modalities of which may differ according to the system's design and configuration. While some blockchains require participants to solve mathematical equations in order to validate data and create additional blocks, others select specific users as validators based on their economic stake in the network.[10]

At any rate, the key advantage of blockchains over centralized ledgers is their virtual immunity to manipulation. Whilst a centralized ledger may be destroyed, hacked or otherwise compromised rather easily, be it by external attackers or by the trusted intermediary himself, data bundled on a blockchain is essentially unerasable and can only be tampered

6 J. Condos et al., 'Blockchain Technology: Opportunities and Risks', *Vermont Legislative Report*, 15 January 2016 (<https://legislature.vermont.gov/assets/Legislative-Reports/blockchain-technology-report-final.pdf>), 4; D.A. Zetzsche, R.P. Buckley & D.W. Arner, 'The Distributed Liability of Distributed Ledgers: Legal Risks of Blockchain', *UNSW Law Research Paper No. 17-52*, July 2018 (<https://ssrn.com/abstract=3018214>), 10.

7 Wilhelm (n. 5), 6; Boucher (n. 4), 5; Condos et al. (n. 6), 6.

8 Zetzsche, Buckley & Arner (n. 6), 8; Wilhelm (n. 5), 6.

9 OECD, *Digital Economy Outlook 2017* (OECD Publishing, 2017), 307; Boucher (n. 4), 5.

10 OECD (n. 9), 308-309; Wilhelm (n. 5), 7; T. Schrepel, 'Collusion by Blockchain and Smart Contracts', 14 January 2019 (<https://ssrn.com/abstract=3315182>), 6.

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with if the attacker not only targets a specific block, but manipulates the entire chain connected to it. This, however, requires a simultaneous attack on every single copy, i.e. on all participating computers, which is extremely difficult.[11] As a consequence, information recorded on a blockchain can neither be deleted nor distorted, thereby providing a maximum of authenticity, transparency and trustworthiness.[12]

2. Governance Mechanisms

Another distinction can be made with respect to a blockchain's governance. In principle, blockchains can be situated on a spectrum ranging from entirely public and permissionless to fully private and permissioned. A permissioned system, on the one end, is basically a private network that limits the number of parties who may access, check, and add transactions to the ledger. On this basis, it is possible for 'mainstream' actors such as banks or governments to maintain significant control over a specific network, e.g. by subjecting applicants to certain vetting procedures before accepting them.[13] A permissionless blockchain, by contrast, is open to the general public and allows anyone who downloads and runs its software from the Internet to participate. Such systems are generally anonymous and permit their participants to conceal their real-world identity, essentially by using an encrypted account that is also known as 'wallet'.[14] As a corollary, the total number of nodes participating at a given time is uncertain, making the system even more resilient to outside attacks.[15]

3. Downsides

Notwithstanding its merits, the blockchain technology also has its flaws. In particular, while the decentralized storage of data generally guarantees that all information is *authentic*, this does not necessarily mean that it is also *accurate*. For instance, if a participant wishes to add a piece of data such as his or her (alleged) birth date to the ledger, the platform will accept it as long as the technical requirements are complied with – even if the person was actually born on another day. A blockchain is hence not automatically prepared to ensure the accuracy of data, but may have to be supplemented with external mechanisms to that end.[16]

11 Wilhelm (n. 5), 7; Boucher (n. 4), 5; OECD (n. 9), 307.

12 OECD (n. 9), 308; Condos et al. (n. 6), 4-5; *The Economist*, 'The Trust Machine', 31 October 2015 (<https://www.economist.com/leaders/2015/10/31/the-trust-machine>).

13 Boucher (n. 4), 5; D. Massessi, 'Public Vs. Private Blockchain In A Nutshell', 12 December 2018 (<https://medium.com/coinmonks/public-vs-private-blockchain-in-a-nutshell-c9fe284fa39f>).

14 See Boucher (n. 4), 17; L.J. Trautman, 'Bitcoin, Virtual Currencies, and the Struggle of Law and Regulation to Keep Pace', 102 (2018) *Marquette Law Rev.* 447, 455 (<https://ssrn.com/abstract=3182867>).

15 Zetzsche, Buckley & Arner (n. 6), 12 (at n. 44: 'security through obscurity').

16 Wilhelm (n. 5), 8; Boucher (n. 4), 19; Zetzsche, Buckley & Arner (n. 6), 16.

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In addition, many DLT solutions struggle with the problem of incentivization. Depending on the network's design and configuration, participants may have to invest enormous time and computing power to solve the mathematical equations, especially since the latter become increasingly complicated as the chain of data is prolonged. In the case of Bitcoin, it has been reported that the annual electricity consumption of the network now exceeds that of entire countries like Nigeria or Serbia.[17] Not to mention environmental concerns, it is obvious that participants will expect some form of consideration for their efforts, which is why the Bitcoin network awards a certain amount of its assets – newly generated Bitcoins – to validators of transactions.[18] Yet even if such remuneration is provided, public blockchains may find it increasingly difficult to handle an ever-growing flood of data.[19]

III. Promises in the Public Sector: An African Perspective

1. Overview

In discussions on the promises of DLT, the focus is usually on private rather than public sector applications. However, it is sometimes overlooked that DLT may also have an important role to play in the public sector, namely in the administration of civic services and the strengthening of the rule of law. Especially in the developing regions of the world where governments are, in principle, the main providers of public goods including justice, security, health, and education, there is often a deficit of trust owing to corruption, nepotism, and the notorious lack of resources.[20] It has thus been submitted that governments will, in fact, be among the 'key users' of the new technology: Insofar as DLTs eliminate the necessity to place personal confidence in a certain intermediary, they could improve government efficiency and restore public trust in the administration of legal institutions.[21] With that in mind, I will now offer an analysis of four of the most important use cases in the public sector which deserve attention from an African perspective, namely the introduction of digital land registries (*infra*, 2.), the strengthening of democratic structures & electoral institutions (3.), the protection of human rights (4.), and the lawful administration of public resources (5.).

17 Boucher (n. 4), 22; Wilhelm (n. 5), 8-9; OECD (n. 9), 311-312.

18 The process is known as 'mining'; see Zetzsche, Buckley & Arner (n. 6), 12; Boucher (n. 4), 5.

19 On this so-called 'scalability problem' see OECD (n. 9), 311; Wilhelm (n. 5), 9 (including further references).

20 See R. Zambrano, *Blockchain: Unpacking the disruptive potential of blockchain technology for human development* (2017), 34 (<http://hdl.handle.net/10625/56662>).

21 J. Berryhill et al., 'Blockchains Unchained: Blockchain Technology and its Use in the Public Sector', *OECD Working Papers on Public Governance No. 28*, 19 June 2018 (<https://dx.doi.org/10.1787/3c32c429-en>), 35-36; Boucher (n. 4), 18-19.

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2. Digital Land Registries

To be sure, the introduction of digital land registries ranks among the most prominent use cases of distributed ledgers in the Global South. In the developing regions of Africa, the lack of reliable land and property registries is considered a major obstacle to economic growth, given that in a majority of countries more than 90% of the rural areas are unregistered or lack official title deeds, with most land being held on the basis of oral agreements or incomplete paperwork.[22] The sale of land is thus encumbered with a substantial degree of uncertainty and corruption, which seems particularly bad in countries like Nigeria.[23] All this may lead to severe land disputes which are all too often settled with violence.[24] In addition, insecure property rights may weaken landowners' incentives to make land-related investments and undermine their ability to use a property as collateral to secure credit, leading to what Peruvian economist *de Soto* famously called 'dead capital'.[25]

Against this backdrop, it has been suggested that land titles in Africa could be registered on a distributed ledger to make property rights more transparent, trustworthy, and immutable.[26] Relevant information could be stored together with GPS coordinates, property descriptions, and drone or satellite photos, enabling purchasers to review the title history of a piece of land before acquiring it. In comparison to the existing structures, this would also improve the position of a loan applicant, given that a bank is of course much more likely to grant affordable credit if the collateral is secure. Besides, a blockchain-based land registry may be preferable with a view to natural disasters such as earthquakes or typhoons; owing to its distributed nature, data stored on a blockchain can be recovered much more easily than traditional paper-based registrations.[27]

On the global stage, digital land registries have reportedly been initiated in Honduras where land title fraud was particularly common,[28] but are also discussed in Georgia and

22 R. Aitken, 'Bitland's African Blockchain Initiative Putting Land on the Ledger', *Forbes Magazine*, 5 April 2016 (available at <https://www.forbes.com>); J. Stolp et al., 'Blockchain and Cryptocurrency in Africa', *Baker McKenzie*, Report of November 2018 (<http://blockchain.bakermckenzie.com/2019/02/12/blockchain-and-cryptocurrency-in-africa>), 4 and 5; Wilhelm (n. 5), 13.

23 Aitken (n. 22); Wilhelm (n. 5), 13.

24 See C. Jochnick, 'Land Rights and Global Development', 10 February 2017 (<https://www.landesa.org/land-rights-global-development-blog>): 'in 2015, […] more than three people were killed each week, on average, defending their land from extractive and other industries'.

25 H. de Soto, *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else* (Basic Books, 2000), 35, 218; also Wilhelm (n. 5), 13 (including further references).

26 Cf. R. Benbunan-Fich & A. Castellanos, 'Digitalization of Land Records: From Paper to Blockchain', 2018 (<https://www.researchgate.net/publication/329222337_Digitalization_of_Land_Records_From_Paper_to_Blockchain>), 3ff.; M. Barbieri & D. Gassen, 'Blockchain – can this new technology really revolutionize the land registry system?', 21 March 2017 (<http://www.notaries-of-europe.eu/index.php?pageID=15101>), 2ff.

27 Cf. R.C. Merkle, 'DAOs, Democracy and Governance', 37 (2016) *Cryonics Magazine* 28 (<http://www.merkle.com/papers/DAOdemocracyDraft.pdf>).

28 See Zambrano (n. 20), 35; Wilhelm (n. 5), 13 (including further reference).

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Haiti and even in the European states of Sweden, Greece, and the UK.[29] In Africa, the state of Ghana is considered to be a forerunner, with a non-profit organization called 'Bitland' leading the way since 2016.[30] Additional centres include Rwanda where a public-private partnership for a digital land registry was sealed in November 2018,[31] or Kenya where both the National Land Commission and the DLT Taskforce expressed their intention to embrace distributed ledgers in creating transparency over land ownership.[32]

From a legal perspective, however, an issue that is sometimes overlooked pertains to the fact that there are, in principle, two different types of public registers: *deed registration* systems on the one hand and *title registration* systems on the other. In a deed registration system, the act of registration is essentially confined to a registration of the legal documents (or 'deeds') affecting interests in a specific piece of land, notably transaction documents such as sale and conveyance contracts.[33] Such registration is usually neither constitutive of ownership nor does it guarantee a person's title, but serves a recording, information-gathering function and may help to resolve conflicts of priority.[34] In a title registration system, by contrast, entitlement to a piece of land is usually *contingent* on official registration, which means that for every parcel the current legal status must be recorded on the basis of an assessment by a public registrar.[35] Such registration will not only secure priority, but carry a legal presumption of accuracy in order to guarantee the validity of the respective right. This presumption is particularly strong in the 'Torrens' system of Australia,[36] but can also be derived from sections 891, 892 of the German Civil Code.[37]

On this basis, it seems that DLT is probably less appropriate to implement a system of *title* registration. Albeit DLT will generally guarantee the authenticity of a ledger, it is not necessarily prepared to ensure its veracity.[38] In particular, given the absence of a professional registrar who could assess the validity of transactions, there seems to be little room

29 N.N. Peiró & E.J.M. García, 'Blockchain and Land Registration Systems', 6 (2017) *EPLJ* 296, 316-318 (<https://doi.org/10.1515/eplj-2017-0017>); Wilhelm (n. 5), 13-14.

30 See <http://landing.bitland.world>; Stolp et al. (n. 22), 4; Zambrano (n. 20), 35.

31 P.H. Madore, 'Overstock's Medici Ventures & Rwanda Government Partner for Blockchain Property Rights Platform', 3 November 2018 (<https://www.ccn.com/overstock-crypto-venture-rwanada-government-partner-for-blockchain-property-rights-platform>).

32 Stolp et al. (n. 22), 5; DLT Taskforce (n. 3), 21.

33 For instance, see T. Hanstad, 'Designing Land Registration Systems for Developing Countries', 13 (1998) *Am. U. Int'l L. Rev.* 650-651 (<https://digitalcommons.wcl.american.edu/auilr/vol13/iss3/2>).

34 Peiró & García (n. 29), 303; Wilhelm (n. 5), 31.

35 Peiró & García (n. 29), 303, 308, 319; Hanstad (n. 33), 651; Wilhelm (n. 5), 31.

36 M. Raff, 'Characteristics of the International Model of Land Title Registration Illuminated by Comparative Study of the German and Torrens System', 1 (2012) *European Property Law Journal* 54, 68-79.

37 See Raff (n. 36), 70-77; B. Arruñada, 'Blockchain's Struggle to Deliver Impersonal Exchange', 19 (2018) *Minn. J.L. Sci. & Tech.* 55, 95 (<https://scholarship.law.umn.edu/mjlst/vol19/iss1/2>).

38 In general *supra*, section II.3.

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for a legal presumption of accuracy in the sense of a Torrens or a German-style registration.[39] German lawyers are hence generally sceptical of a 'blockchainization' of the German land registry system, and in the developing regions of Africa, a blockchain-based title registry may be even more misplaced. Besides, it is generally accepted that a modern land title registry should not only display the ownership structure of a property, but also comprise more sophisticated entries such as pre-emptive rights, easements, or different types of mortgages. In the light of their complexity, however, it seems questionable whether such entries could be adequately recorded without the guidance of a legally trained intermediary.[40]

On the other hand, DLT solutions may be perfect for the purpose of deed registration. Insofar as a blockchain can provide for a tamper-proof storage of the relevant documentation, pre-transaction due diligence procedures which are necessary to review the legal status of a property would be simplified.[41] Governments might also consider the introduction of a hybrid model, namely a combination of deed and title registration which is only *partially* supported by a blockchain. For instance, a conventional intermediary (such as a government registrar or a notary public) might be charged with the notarization of a real estate transaction in a first step, which could then, together with the underlying documents, be registered on the blockchain in a second.[42] In fact, it seems that hybrid solutions which essentially support the function of conventional intermediaries are already favoured in countries such as Sweden[43] and might also be preferable in Africa, given that numerous African jurisdictions have adopted hybrid systems of deeds and title registration anyway.[44] In such a context, a private and permissioned blockchain[45] is probably the most promising way to go.[46]

Admittedly though, regardless of the model that is eventually chosen, it may be difficult to 'fix' the applicable status quo from which the system can start out. Owing to the obscurity of current title situations and the incompleteness of existing paperwork, African governments may have to consider some form of legal consolidation before registration can be-

39 Peiró & García (n. 29), 308, 310; Barbieri & Gassen (n. 26), 10-12; Wilhelm (n. 5), 32.

40 Barbieri & Gassen (n. 26), 11; L. Griggs et al., 'Blockchains, Trust and Land Administration – the Return of Historical Provenance', 21 February 2019 (<https://ssrn.com/abstract=3325558>), 2, 17-19.

41 Peiró & García (n. 29), 306-310, 316; Arruñada (n. 37), 96; Wilhelm (n. 5), 32-33.

42 Similarly Peiró & García (n. 29), 318-320; Arruñada (n. 37), 105; Griggs et al. (n. 40).

43 Peiró & García (n. 29), 317.

44 See S.R. Simpson, *Land Law and Registration* (Cambridge University Press, 1976), 105 (for South Africa); C.W. Dickerman et al., 'Security of Tenure and Land Registration in Africa', *LTC Paper* 137, 1989 (<https://core.ac.uk/download/pdf/6778934.pdf>), viii-xiii.

45 *Supra*, section II.2.

46 Wilhelm (n. 5), 33; J.M Graglia & C. Mellon, 'Blockchain and Property in 2018: At the End of the Beginning', 12(1-2) *Innovations* 90 (2018) (<https://www.mitpressjournals.org/doi/abs/10.1162/inov_a_00270>), 95; Peiró & García (n. 29), 311; Arruñada (n. 37), 96. However, the Bitland project in Ghana seems to use a public blockchain network; cf. Aitken (n. 22).

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gin.[47] However, this issue is by no means idiosyncratic to the adoption of DLT in particular, but constitutes a recurring topic on developing nations' regulatory agenda.[48]

3. Democracy and Elections

Another prominent use case is 'e-voting'. All over the world, democratic structures in general and public elections in particular are vulnerable to fraud and manipulation – especially in the case of a paper ballot, but also if technical tools such as voting machines are employed.[49] The result is all too often a severe conflagration of post-election violence, with the cases of Kenya (2007/8), Zimbabwe (2008, 2018), or Gabon (2016) providing infamous examples from the African continent. The advent of distributed ledgers hence prompted the idea of a blockchain-based electoral system, capitalizing on the technology's authenticity and transparency with a view to developing countries in particular.[50] In addition, such systems could relieve the citizens from the logistical strains of travelling to (and queuing at) the polling site, notably by enabling them to cast their votes from afar using personal computers or a smart phone.[51] To these ends, African nations were among the first to embrace the concept of e-voting, with the country of Sierra Leone reportedly running its 2018 presidential elections on a private blockchain network.[52] Albeit the latter was in fact little more than a test run,[53] it contributed to Sierra Leone's reputation as the continent's first 'smart country', motivating nations such as Kenya to pursue a similar approach.[54]

However, the devil seems to be in the detail. Firstly, in a DLT-based electoral system there is a potential conflict between the necessity to identify and authenticate voters on the

47 Cf. Peiró & García (n. 29), 306-307 ('The primary application requires a high degree of evidence, in the old systems it was a purge of rights and in some jurisdictions is needed a judicial decision.'); M. Busstra, 'Human Rights' in UNOPS (ed.), *The Legal Aspects of Blockchain* (UNOPS, 2018), Ch. 4, 44.

48 See, for instance, Hanstad (n. 33), 666 (writing from the perspective of 1998).

49 Cf. Boucher (n. 4), 12-13; V. Tepecik, 'Future of Democracy: Blockchain Voting', 4 (2019) *JOMUDE* 11 (<http://www.jomude.com/index.php/jomude/article/view/61/126>), 12ff.

50 F.S. Hardwick et al., 'E-Voting with Blockchain: An E-Voting Protocol with Decentralisation and Voter Privacy', July 2018 (<https://arxiv.org/pdf/1805.10258.pdf>); Stanford Graduate School of Business, *Blockchain for Social Impact 2019* (<https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/csi-report-2019-blockchain-social-impact.pdf>), 20; Boucher (n. 4), 12; K. Schmidt & P. Sandner, 'Solving Challenges in Developing Countries with Blockchain Technology', *FSBC Working Paper*, October 2017 (<https://medium.com/@philippsandner/solving-challenges-in-developing-countries-with-blockchain-technology-78ec9b01bae3>), 17.

51 See Tepecik (n. 49), 14; Wilhelm (n. 5), 14-15.

52 Cf. R. Perper, 'Sierra Leone just became the first country in the world to use blockchain during an election', 14 March 2018 (<https://www.businessinsider.de/sierra-leone-blockchain-elections-2018-3?r=US&IR=T>).

53 U.W. Chohan, 'Blockchain Enhancing Political Accountability? Sierra Leone 2018 Case', 16 March 2018 (<https://ssrn.com/abstract=3147006>); Stolp et al. (n. 22), 16-17.

54 DLT Taskforce (n. 3), 16, 86-87.

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one hand, i.e. to ensure their eligibility to participate in the election, and the need to guarantee ballot secrecy as a democratic principle on the other. Owing to the distributed nature and transparency of many blockchain applications, it has been suggested that ballot secrecy may be difficult to maintain and that the players running the ledger could be in a position to 'match' the personal data of the voters with the very votes that are being cast.[55] Although this would be most problematic in a public and permissionless blockchain network, it might also violate democratic standards if governments chose a private and permissioned DLT.[56] According to recent research, however, it is allegedly possible to unlink personal voter information from the actual votes themselves, for instance by using an 'ElGamal' encryption technique[57] and/or so-called 'mix networks' that are designed to protect voters' anonymity.[58] Respective solutions are already being tested, e.g. by the 'Agora' voting platform which was reportedly used during the 2018 election in Sierra Leone.[59]

Secondly, even if the applicable secrecy requirements are met, concerns may be raised in respect of some platforms' capacity to audit voting records, for instance if the system records votes in a way that makes them immediately available.[60] If the voters are in a position to monitor the developing results while the election is still ongoing, this could violate the standards of election fairness and encourage 'tactical voting'.[61] Similarly, if the system (merely) enables a voter to control whether his or her individual vote has been included in the tally, which could be done using traceable 'voting tokens' on-chain,[62] this might foster an illicit sale of votes as the 'seller' (voter) would be in a position to prove to the 'buyer' that he or she actually voted for a certain candidate or party as requested.[63]

Finally, albeit DLT might significantly reduce the costs of elections in the long run,[64] its implementation in Africa will entail a number of practical challenges. For instance, in areas without adequate mobile or Internet connections, voters' ballots may still have to be cast outside the respective blockchain system, meaning that a third party government intermediary

55 Cf. Tepecik (n. 49), 19; A. Wagner, 'Can Blockchain-Enabled Voting Meet Security and Secrecy Standards?', 9 April 2019 (<http://chicagopolicyreview.org/2019/04/09/can-blockchain-enabled-voting-meet-security-and-secrecy-standards>).

56 As to the different governance mechanisms cf. *supra*, section II.2.

57 See, for instance, R. Singh & S. Kumar, 'Elgamal's Algorithm in Cryptography', December 2012 (<https://pdfs.semanticscholar.org/f45a/8b96b010e476129be5a66ab3be4e5e7490aa.pdf>).

58 Tepecik (n. 49), 19; F. Fusco et al., 'Crypto-Voting, a blockchain based e-voting system', January 2018 (<https://dx.doi.org/10.5220/0006962102230227>), sub 2./3.

59 See <https://www.agora.vote>; DLT Taskforce (n. 3), 52.

60 As to this possibility cf. Tepecik (n. 49), 15ff.

61 Wagner (n. 55).

62 Tepecik (n. 49), 15, 18; Çabuk et al., 'A Survey on Feasibility and Suitability of Blockchain Techniques for the E-Voting Systems', 7 (2018) *IJARCCE* 124, 127.

63 From a German perspective C. Welzel et al., 'Mythos Blockchain: Herausforderung für den öffentlichen Sektor', April 2017 (available online at <https://www.oeffentliche-it.de>), 22.

64 Tepecik (n. 49), 14.

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will still be needed to legitimize them.[65] As a consequence, that intermediary might still be in a position to manipulate the tally, be it voluntarily (for political reasons) or as a matter of personal negligence. Moreover, while countries with smaller populations are probably in a better position to convert their voting systems from paper- to blockchain-based infrastructures, larger countries may face substantial scalability concerns owing to the extensive amount of data to be handled.[66] The latter may be particularly grave if a public and permissionless DLT is chosen, although it seems that most of the current voting projects favour private and permissioned DLTs.[67] In any event, scientific research is still far from reaching a definitive solution that could completely replace more conventional voting systems; in other words, it seems that blockchain-based electronic voting is still on a rocky road to maturity.[68]

4. Human Rights Protection

Another field in which DLT may provide assistance is the protection of human rights. On the face of it, contemporary Africa seems to be blessed with a relatively stable institutional framework in respect of human rights, be it at the regional (i.e. African Union), the sub-regional (e.g. ECOWAS, SADC), or the domestic level of jurisdiction.[69] However, in spite of this impressive legal framework, the problem lies on the side of enforcement: In the wake of disruptive events such as political conflicts, civil wars, and the disintegration of entire nation states, African governments find it increasingly difficult to deliver on the promise of a more humane society, be it in terms of abstaining from human rights abuses themselves or in terms of protecting the population from violations conducted by third party protagonists. This dilemma is exacerbated even further by developments such as climate change which undermines people's rights to life, health, food, water, and housing,[70] or the growing economic strains of capitalist-driven globalization.[71]

65 See C. Lee and J. Mueller, 'Can Blockchain Unlock the Investment Africa Needs?', 12(3-4) *Innovations* 80, 86 (2018) (<https://www.mitpressjournals.org/doi/abs/10.1162/inov_a_00277>).

66 Cf. Wagner (n. 55). As to such scalability issues more generally *supra*, section II.3.

67 See H. Patil et al., 'Blockchain Based E-Voting System', 18 May 2019 (<https://dx.doi.org/10.2139/ssrn.3422954>), 7; more generally D. Tambanis, 'Blockchain Application: Election Voting', 5 February 2019 (<https://medium.com/bpfoundation/blockchain-applications-election-voting-a1436e7d10cb>).

68 Çabuk et al. (n. 62), 126; Fusco et al. (n. 58), sub 2.

69 Cf. European Parliament, *Human rights protection mechanisms in Africa: Strong potential, weak capacity*, February 2013 (<http://www.europarl.europa.eu/RegData/etudes/briefing_note/join/2013/491487/EXPO-DROI_SP(2013)491487_EN.pdf>), 4, picturing a 'thick web of overlapping international, continental and national-level instruments'. For a general overview see A. Izumo, 'African Human Rights System Research Guide', *Columbia University*, 1 July 2015 (<http://library.law.columbia.edu/guides/African_Human_Rights_System#Background_Sources>).

70 Cf. M. Addaney et al., 'The Climate Change and Human Rights Nexus in Africa', 9 (2017) *Amsterdam Law Forum* 5-28 (<http://amsterdamlawforum.org/article/view/402>).

71 In detail P.T. Zeleza, 'The Struggle for Human Rights in Africa', 41 (2007) *Canadian Journal of African Studies* 474-506 (<https://www.jstor.org/stable/40380100>).

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In a few areas at least, DLT may provide some sort of an antidote to this conundrum, which can be illustrated with a view to the mining industry in particular. In many regions of Africa, minerals such as diamonds, gold, tantalum, or coltan are mined under egregiously inhumane conditions, usually in order to finance an insurgency, a warlord, or an invading army's efforts. Relevant violations include exploitative practices against indigenous communities, slavery, and child labour, which were famously depicted in the 2006 Hollywood movie 'Blood Diamond'.[72] In spite of the famous 'Kimberley Process', an international certification scheme to improve market transparency and to deter diamond producers from participating in illegitimate activities,[73] violations prevail as falsification, fraud, and mineral smuggling still occur along supply chains.[74] As a consequence, so long as there is no unimpeachable way to guarantee the origin of a specific mining product, illegitimate practices will be difficult to weed out.

This is where blockchain technology comes in. According to IT experts, it is possible to catalogue diamonds and other minerals on a distributed ledger in order to create transparency about their provenance, tracking the stones from the moment they are mined until they are eventually sold to consumers or manufacturers.[75] For example, in January 2018 South African-founded diamond company De Beers already announced a programme using DLT to ensure that its diamonds are authentic, conflict-free, and natural.[76] The underlying venture ('Tracr') reportedly assigns every diamond with a unique 'Global Diamond ID' that records its characteristics regarding carat, clarity, and colour on the chain, allowing customers and retailers to monitor the stone's journey and to steer clear of conflicted specimen.[77]

Against this backdrop, governments in Africa and elsewhere might take up the thread and adopt legislation making DLT mineral tracking compulsory for every player in the industry. Albeit it is already foreseeable that Western importers will be coming more and more under pressure to comply with the applicable (non-binding) human rights standards of

72 See <https://en.wikipedia.org/wiki/Blood_Diamond>.

73 See C. Wright, 'Tackling conflict diamonds: the Kimberley process certification scheme', 11 (2004) *International Peacekeeping* 697-708 (<https://doi.org/10.1080/1353331042000248731>).

74 Cf. A. Howard, 'Blood Diamonds: The Successes and Failures of the Kimberley Process Certification Scheme in Angola, Sierra Leone and Zimbabwe', 15 (2015) *Wash. U. Global Stud. L. Rev.* 137-159 (<https://openscholarship.wustl.edu/law_globalstudies/vol15/iss1/8>).

75 D. Pinkert et al., 'Blockchain technologies offer transparency that could improve human rights practices', 24 January 2019 (<https://www.openglobalrights.org/blockchain-technologies-offer-transparency-that-could-improve-human-rights-practices>); *Harvard University Blockchain Lab*, 'How Blockchain Could End the Trade in Blood Diamonds' (<https://blogs.harvard.edu/blockchain/how-blockchain-could-end-the-trade-in-blood-diamonds>).

76 See <https://www.debeersgroup.com/media/company-news/2018/alrosa-pilots-tracr-platform>; Stolp et al. (n. 22), 3; DLT Taskforce (n. 3), 57-58. Also Wilhelm (n. 5), 16-17.

77 S. O'Neal, 'Diamonds Are Blockchain's Best Friend: How DLT Helps Tracking Gems and Prevents Fraud', 6 February 2019 (<https://cointelegraph.com/news/diamonds-are-blockchains-best-friend-how-dlt-helps-tracking-gems-and-prevents-fraud>).

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the United Nations (UN)[78] and the OECD regarding the organization of supply chains,[79] additional legal measures could be helpful to finally put an end to the notorious atrocities.

5. Public Resources and Anti-Corruption

Finally, blockchain technology has an important part to play in the lawful administration of public resources and the fight against corruption. Among the numerous challenges in this respect,[80] prominent case groups include the phenomenon of 'ghost employee fraud', namely the compensation of non-existent civil servants that have dishonestly been put on a government's payroll,[81] the bribery of decision makers in the administration of social welfare,[82] the embezzlement of foreign aid and direct investments,[83] or corruptive behaviour in the context of public procurement.[84]

DLT might alleviate these issues on the basis of so-called 'smart contracts'. Generally speaking, a smart contract is a piece of software that executes a real-life contract which the parties have transformed into a blockchain-based computer code.[85] For example, if the parties of a sales contract have successfully negotiated the terms of their agreement, it is not only possible to store the latter safely on the ledger, but also to have the system automatically fulfil all or some of the parties' obligations, e.g. by disbursing money from the buyer's account as soon as the payment deadline has expired.[86] As a consequence, the

78 Cf. the United Nations' Global Compact (<https://www.unglobalcompact.org>) and the Guiding Principles on Business and Human Rights (<https://www.ohchr.org/documents/publications/GuidingprinciplesBusinesshr_eN.pdf>).

79 Cf. the OECD's 'Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas', 20 March 2013 (<https://doi.org/10.1787/9789264185050-en>).

80 From a general perspective N. Hoffmann, 'African perspectives on corruption', 36 (2018) *Journal of Contemporary African Studies* 425-432 (<https://doi.org/10.1080/02589001.2018.1584718>).

81 See H. Moyo, 'A Paper on Ghost Worker Syndrome: A Panacea to Zimbabwe's Bloated Public Service', 5 (2017) *IJSSHR* 674-683; A.T. Nafiu, M.I. Yalo & D.J. Aduku, 'Assessment of the Variations of Ghost Employee Fraud in Nigeria: 2008-2015', 8 (2016) *European Journal of Business and Management* (<https://pdfs.semanticscholar.org/3cef/19eacbd74d3e6f5479d1a765810996857706.pdf>).

82 H. Crowe, *The Impact Of Political Corruption on Social Welfare In The Federal Republic of Nigeria* (2011) (<https://stars.library.ucf.edu/etd/1913>); Boucher (n. 4), 18.

83 S. Asongu, 'The Evolving Debate on the Effect of Foreign Aid on Corruption and Institutions in Africa' in B.M. Arvin & B. Lew (eds.), *Handbook on the Economics of Foreign Aid* (Edward Elgar Publishing, 2015), Ch. 19, 313-322.

84 So-called 'bid rigging' etc.; A. Appoloni & J.M. Mushagalusa Nshombo, 'Public Procurement and Corruption in Africa: A Literature Review' in F. Decarolis & M. Frey (eds.), *Public Procurement's Place in the World* (Palgrave Macmillan, 2014), 185-208.

85 For details cf. Wilhelm (n. 5), 28-30; Raskin (n. 35), 309-310, 320.

86 See OECD (n. 9), 314ff.

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blockchain may prevent otherwise necessary lawsuits and/or relieve the parties from appointing a third person as trustee, thereby keeping transaction costs to a minimum.

In Africa, a number of governments have already implemented smart contracts to mitigate some of the corruption issues mentioned above. In respect of 'ghost workers', it has been reported that Tanzania made considerable progress in clearing out government payrolls, ending the monthly outflow of 430 billion Tanzanian shillings in salaries to dishonest employees.[87] Similarly, blockchains are already being adopted in the administration of development aid,[88] with the German *Kreditanstalt für Wiederaufbau* (KfW) development bank's 'TruBudget' platform providing a most prominent example.[89] Based on a permissioned private blockchain, TruBudget enables donors to control how their donation money is spent, thereby discouraging an embezzlement of funds by local agents.[90] Its concept is already being used for a project in Burkina Faso, among others.[91] In addition, DLT and smart contracts might improve the anti-bribery resilience of social welfare programmes, given that the underlying network could automatically determine the circumstances under which social payments must be granted, and the conditions under which they must be stopped.[92] As regards public procurement, DLT and smart contracts are also being advocated, notably to prevent an after-the-fact-tampering with submitted bids and certain other types of rigging.[93]

However, adopting smart contracts and DLT to tackle corruption on a larger scale is not entirely without problems. Aside from the fact that government officials may have little incentives to launch a budget-tracking system if they are actually benefitting from the existing (ineffective) structures,[94] the law and legality of smart contracts may be difficult to determine under existing legal rules. As lawyers' possibilities to assess these issues on an abstract legal level are limited,[95] it seems that each jurisdiction will have to find its own individual, tailor-made regulatory approach.

87 See N. Mathew, 'Africa Adopting Blockchain To Weed Out Ghost Workers', 15 December 2018 (<https://newconomy.media/news/africa-adopting-blockchain-to-weed-out-ghost-workers>).

88 A. Zwitter, 'Blockchain for humanitarian action and development aid', 3:16 (2018) *J. Int. Humanit. Action* (<https://link.springer.com/article/10.1186/s41018-018-0044-5>); DLT Taskforce (n. 3), 56.

89 Cf. the TruBudget website at <https://openkfw.github.io/trubudget-website>.

90 Schmidt & Sandner (n. 50), 10.

91 KfW, 'Digital Solutions for everyone: KfW releases TruBudget blockchain software', 3 April 2019 (<https://www.kfw.de/KfW-Group/Newsroom/Latest-News/Pressemitteilungen-Details_515008.html>).

92 Berryhill et al. (n. 21), 19 (para. 56), 24; cf. also Schmidt & Sandner (n. 50), 9-10.

93 With a view to Africa in particular see M. Iheukwumere, 'Leveraging Blockchain to Combat Procurement Corruption', 19 August 2019 (<https://globalanticorruptionblog.com/2019/08/19/leveraging-blockchain-to-combat-procurement-corruption>).

94 Schmidt & Sandner (n. 50), 10.

95 In detail Wilhelm (n. 5), 9, 28-30 (including further references).

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IV. Challenges and Conflicts

In spite of the numerous opportunities which DLT has to offer, implementation of the technology is faced with a variety of impediments. Among the challenges and conflicts that are being considered with a view to developing countries in particular, some can be classified as legal whereas others should be approached from an economic or rather technical point of view.[96] In the following, I am going to focus on a set of three particular issues which I consider most important in the context of public sector applications.[97]

1. The Tension Between DLT and Data Protection Law

Perhaps most importantly, DLT and blockchains may raise serious concerns in respect of data protection legislation.[98] In recent years, many nations have adopted sophisticated data protection legislation to promote individual data sovereignty, i.e. to enhance natural persons' control over personal data and information.[99] In the European Union, the General Data Protection Regulation 2018[100] (GDPR) introduced a set of substantive data protection rights and principles, notably to keep pace with technological developments in the age of globalisation. More specifically, any 'data controller' within the meaning of article 4(7) GDPR must ensure that the personal data of a 'data subject' is always accurate and up to date, otherwise the latter may claim rectification under article 16 GDPR. In addition, there is a 'right to be forgotten' enshrined in article 17 GDPR, stipulating that a data controller may be obliged to erase a data subject's personal data without undue delay upon request.[101] Similar rights have been created in Africa, including countries like Nigeria, Niger, South Africa, or Mauritania.[102] In fact, based on the African Union's Data Protection Convention of June 2014 and the ECOWAS Data Protection Act of 2010, it seems that African awareness of data protection is consistently on the rise, with a reported total of 17 states having enacted comprehensive data protection legislation.[103]

96 Cf. already Wilhelm (n. 5), 19ff.

97 For further analysis see Wilhelm (n. 5), 33-36.

98 As to the following see also Wilhelm (n. 5), 36-38.

99 For an overview see Consumers International, 'The State of Data Protection Rules Around the World', May 2018 (<https://www.consumersinternational.org/media/155133/gdpr-briefing.pdf>).

100 Regulation (EU) 2016/679 of 27 April 2018, OJ No. L 119 of 4 May 2016, 1.

101 For further details (also on other rights and principles under GDPR) see M. Finck, 'Blockchains and Data Protection in the European Union', 1 (2018) *EDPL* 17, 28ff. (<https://edpl.lexxion.eu/article/edpl/2018/1/6>).

102 See, for instance, G. Greenleaf & B. Cottier, 'Data privacy laws and bills: Growth in Africa, GDPR influence', 152 (2018) *PL&B International* 11, 12 (<https://ssrn.com/abstract=3212713>).

103 C. Rich, 'A Look at New Trends in 2017: Privacy Laws in Africa and the Near East', 16:6 (2016) *Bloomberg BNA World Data Protection Report* 1-13; Deloitte, *Privacy is Paramount: Personal Data Protection in Africa*, 2017 (<https://www2.deloitte.com/za/en/pages/risk/articles/personal-data-protection-in-africa.html>), 3ff.

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That being said, DLT and data protection may collide in a variety of ways. First of all, although it is widely accepted that DLT-stored information may well constitute 'personal data' for the purpose of data protection legislation,[104] it seems that the underlying statutes are typically designed for *centralized* data silos in particular, namely for information intermediaries such as Google, Amazon, or Facebook. In the EU, there is hence considerable confusion about their application to distributed ledgers, starting with the very question of who, if anyone, might qualify as a 'data controller' under article 4(7) GDPR. Whilst the latter may cause less of a headache in a private blockchain network which is essentially controlled by a government authority or agency, it seems that there is no satisfying answer concerning public DLTs which are run by an unknown number of pseudonymous nodes.[105] In addition, DLT is at odds with a data subject's right to rectification and the right to be forgotten, given that data stored on a blockchain is conceptually irreversible.[106] All of this is particularly disturbing in the case of intimate or politically sensitive personal information such as electoral data,[107] but has also raised concerns in the context of land registration,[108] among others.

However, although it has been submitted that DLT will in most – if not all – instances be incompatible with existing data protection legislation, it seems that no issue is actually insurmountable. As regards the right to rectification and the right to be forgotten, it may be a solution to store protected personal data in a modifiable database off-chain and merely link it to the ledger through a so-called 'hash pointer'. On this basis, it may be possible to allow GDPR-induced data modification whilst the blockchain could still hold proof that the referenced data is authentic.[109] Beyond that, numerous alternatives are currently being tested, and research is still largely in a fledgling stage. Yet in turn, regulators are also called upon to facilitate the reconciliation of data protection and DLT, e.g. by showing more flexibility in the application of legal principles.[110] Albeit data protection is undoubtedly a high-value policy objective, it would be misplaced to sacrifice technological progress at all costs for the sake of an overly formalistic regulatory approach.

2. Education and Infrastructure

Apart from that, a point that cannot be made strongly enough is that education and infrastructure development are essential. In respect of the former, African states should be aware

104 See Finck (n. 101), 22-23.

105 In detail Finck (n. 101), 26-27.

106 This is, in fact, the most salient feature of DLT; cf. *supra*, section II.1.

107 As to respective DLT use cases *supra*, section III.3.

108 See Peiró & García (n. 29), 311; B. Makala & A. Anand, 'Blockchain and Land Administration' in UNOPS (ed.), *The Legal Aspects of Blockchain* (UNOPS, 2018), Ch. 9, 148.

109 See E. Politou et al., 'Blockchain Mutability: Challenges and Proposed Solutions', 16 July 2019 (<https://arxiv.org/pdf/1907.07099.pdf>), 6-7; Finck (n. 101), 23.

110 Cf. Finck (n. 101), 18.

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that DLT innovations require solid skills in information technology to be economically viable.[111] Such expertise is not only required in the private sector, namely among entrepreneurs and their respective workforce, but also among lawmakers, regulators, and public authorities. Governments should hence invest in educational programmes and consider the establishment of dedicated working groups, round tables, and consultation platforms with the private sector.[112] Promising projects have already been introduced in countries like Mauritius,[113] Kenya,[114] and South Africa.[115] In this respect, although Africa may still be lacking a sufficient amount of experts, demographics on the continent can be regarded as an advantage, given that a large proportion of its population is young and eager to learn and seems to have an overall pro-technological sentiment. The latter is also illustrated by the numerous blockchain conferences that are regularly held in Africa, including those of Kampala (Uganda)[116] or the upcoming 'Blockchain Africa Conference 2020' in Johannesburg (South Africa).[117]

Similarly, in order to promote the success of DLT, African nations must invest in the underlying infrastructure. Without reliable Internet connections and a stable supply of electricity, it may be difficult to ensure that DLT solutions actually reach the people and businesses that would benefit the most.[118] The 'Bitland' organization in Ghana[119] reportedly alleviates this issue by establishing local stations with independent Internet and solar energy facilities wherever these are needed.[120] In addition, a preliminary solution could be to integrate the underlying networks with more established regional communication platforms that rely on conventional mobile phone connections: In the digital payment sector, a German organization named 'Bitwala'[121] reportedly enabled users to transfer Bitcoins to recipients in Kenya, Tanzania, Uganda, and Nigeria through the SMS-based payment system of M-Pe-

111 DLT Taskforce (n. 3), 37; Zambrano (n. 20), 9-10, 24, 46-47.

112 Cf. Berryhill et al. (n. 21), 22-23, 36-37; DLT Taskforce (n. 3), 37.

113 Cf. W. Ayugi, 'Mauritius-based Horizon Africa Launches Blockchain Education Platform for Africans', 10 April 2019 (<https://bitcoinafrica.io/2019/04/10/horizon-africa-launches-blockchain-education-platform>).

114 Cf. online at <https://bitcoinke.io/2018/04/blockchain-education-in-kenya>.

115 Cf. M. Doyle, 'The "Why" behind South Africa's Strong Blockchain Community', 2 August 2018 (<https://medium.com/linum-labs/the-why-behind-south-africa-s-strong-blockchain-community-f661c66b2160>).

116 Cf. <https://blockchainconferences.io/conferences/africa-blockchain-conference-2019>.

117 For information see <https://blockchainafrica.co>.

118 Cf. DLT Taskforce (n. 3), 37; Schmidt & Sandner (n. 50), 7, 19.

119 *Supra*, section III.2. (concerning digital land registries).

120 L.C. Bates, 'Bitland Global', *White Paper* of 1 November 2016, 6ff. (<http://www.bitland.world/wp-content/uploads/2016/03/Bitland_Whitepaper.pdf>); Schmidt & Sandner (n. 50), 7.

121 See <https://www.bitwala.com>.

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sa.[122] Whether this could also be an option for the strengthening of legal institutions in the public sector is admittedly uncertain; at least in the long run, it seems that more bespoke infrastructural facilities are probably indispensable, which might make excellent projects for institutions like the World Bank or the African Development Bank.[123]

3. Environmental Issues

The third issue pertains to the energy consumption and environmental issues of permissionless public blockchains in particular, notably the one underlying Bitcoin.[124] Although it has recently been suggested that Bitcoin's impact on the environment may have been overestimated,[125] it seems that the technology's long-term sustainability will be questionable if its energy concerns are not entirely dispelled. In this respect, additional research is probably indispensable to help develop more efficient and eco-friendly DLT solutions, which is already being undertaken by various researchers across the globe.[126]

In the context of public sector applications, the solution may be rather simple. Instead of relying on a permissionless public blockchain, it seems that a private and permissionless DLT may be preferable in many of the relevant use cases anyway. I already mentioned that a private blockchain may indeed merit preference when it comes to land registration, digital elections, or the administration of public resources,[127] given that such systems will usually need to remain under the general control of the government. However, private blockchains may also be preferable for the organization of supply chains in the interest of human rights. Besides, it seems that the proliferation of renewable energies may offer a perspective for the sustainability of many DLT solutions in the future; in fact, it has already been reported that DLTs themselves may have an important role to play in the development of renewable energy solutions, e.g. in order to facilitate the development of small-scale electricity trading markets as a means to improve power accessibility in Africa's rural areas.[128]

122 Cf. L. Coleman, 'Bitwala Enables Free Bitcoin Transfers to MPesa Accounts in Africa', 9 March 2017 (<https://www.ccn.com/bitwala-allows-users-to-send-bitcoin-free-to-mpesa-accounts>).

123 Schmidt & Sandner (n. 50), 19.

124 *Supra*, section II.3.

125 See S. Wan, 'Bitcoin's Impact On The Environment Is Largely Fiction, Claims Prominent Energy Specialist', 15 August 2019 (<https://www.newsbtc.com/2019/08/15/bitcoins-impact-on-the-environment-is-largely-fiction-claims-prominent-energy-specialist>).

126 See, for instance, P. Jacquet & B. Mans, 'Green Mining: toward a less energetic impact of cryptocurrencies', 21 December 2018 (<https://arxiv.org/abs/1801.07814>).

127 *Supra*, sections III.2., III.3., III.5.

128 E.g. N. John, 'Blockchain can revolutionise the energy industry in Africa', 29 November 2018 (<https://www.weforum.org/agenda/2018/11/blockchain-will-change-the-face-of-renewable-energy-in-africa-here-s-how>).

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V. Conclusion and Outlook

In June 2015, the London-based newspaper *The Economist* published an article titled 'African energy: The leapfrog continent', analysing Africa's prospects to bypass carbon-intensive power generation and move directly into the age of renewable energy.[129] Indeed, African nations have repeatedly demonstrated their ability to leapfrog many Western countries in technological concerns, the most prominent case being mobile phone usage which soared from about 3% in the early 2000s to more than 80% in 2015.[130]

In spite of its challenges and conflicts, the next big thing could be the Blockchain. Whilst the lion's share of the discussion so far arguably focused on the Global North, it seems that the developing regions of the world may actually have the highest profits to reap from a transition to the new technology.[131] To make the most of this opportunity, policymakers should create an environment that allows for effective experimentation and learning: As a first step, it is always important to clearly identify a particular problem which is calling for a solution,[132] meaning that governments and private players alike should try to get 'as specific as possible'. Put differently, '[s]ince blockchain models and the value they provide differ greatly across use cases, analysis should focus on specific applications. This will require pairing sector specialists with technical experts, ideally with a policy person in the mix.'[133] Depending on the circumstances, it may well be that a blockchain is actually not the best possible solution to overcome a specific issue;[134] it is therefore necessary to remain critical, even in spite of the general enthusiasm.

All of this also goes for the legal side of the equation. On the one hand, African governments should ensure that any DLT-based solution is implemented along with legislation that actually recognizes its results as a legal threshold, thereby providing certainty for government agencies and the general public alike. To that end, governments might either adopt a comprehensive set of rules, perhaps drawing from the earlier example of Liechtenstein (with its 'Blockchain Act' of May 2019[135]), or by interpreting existing laws in a targeted

129 Available at <https://www.economist.com/middle-east-and-africa/2015/06/06/the-leapfrog-continent>.

130 Stolp et al. (n. 22), Preface; *The Economist*, 'In much of sub-Saharan Africa, mobile phones are more common than access to electricity', 8 November 2017 (<https://www.economist.com/graphic-detail/2017/11/08/in-much-of-sub-saharan-africa-mobile-phones-are-more-common-than-access-to-electricity>).

131 Cf. Busstra (n. 47), 48.

132 DLT Taskforce (n. 3), 37 ('A Blockchain solution may not be effective without clear identification of a pressing problem').

133 M. Pisa, 'Reassessing Expectations for Blockchain and Development', 12(1-2) *Innovations* 80 (2018) (<https://www.mitpressjournals.org/doi/pdf/10.1162/inov_a_00269>), 87. Similarly DLT Taskforce (n. 3), 37.

134 DLT Taskforce (n. 3), 37.

135 See <https://impuls-liechtenstein.li/blockchain-gesetz> and <https://impuls-liechtenstein.li/wp-content/uploads/2019/06/bua_054_2019_tvtg.pdf>.

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way and adopting tailor-made legislation in specific areas. On the other hand, lawmakers should also be aware that just like any other technological innovation, DLT is subject to rapid developments and technological progress.[136] It is hence conceivable that the technology as we know it today may already be outdated in a couple of years to come, which may also render potential first-generation DLT regulation (partially) obsolete. As far as possible, lawmakers should therefore try to set out legal requirements in a flexible, technology-neutral way, most notably to give future developers and public authorities the necessary leeway to react.[137]

136 Zambrano (n. 20), 53-54; Wilhelm (n. 5), 42.

137 Cf. DLT Taskforce (n. 3), 37; Wilhelm (n. 5), 42.

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