Disruptive Technologies: Foundation for Sustainable Land Information Management Reengineering in Developing Countries [1]

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Abstract

In light of the currently experienced land titling irregularities, tenure insecurity, fraudulent practices, and document processing delays of land administration in developing countries, a compendium of empiricisms heighten instaurations of the Internet of Things digitalization hypothesis in the management of land information. At present, this thrust is accentuating globally, and rightly so, given the spate of interest in adoption of disruptive technologies for sustainable land administration. However, what is yet unknown is the potentials of cryptographic blockchain technology in sustainable land information management (LIM) in developing countries. We aim to present new research perspectives on the issues of blockchain integration in LIM using a mixed-methods approach. Our methodology employed e-questionnaire to elicit data from a sample frame of 323 LIM staff in Nigeria, which was further subjected to analysis using One-Sample t-test. Our findings show the blockchain applications to sustainable LIM, while identifying plausible challenges encroaching on its adoption. Recommendations presented strategies for attenuating the challenges while offering pertinent research insights for further studies on the discourse.

Keywords: Blockchain, Sustainability, Land administration, Management Information System, Land titling irregularities, IoT.

Land Information Management: An Overview

Land is not just 'the' constant in the existence of all living creatures, it is also hugely consequential to its survival. This is consistent with Umeh's (1973) view that when one touches on land, you touch on everything in the society. By this assertion, it becomes immediately clear that every human endeavour revolves around this entity but also presents a perturbing reality when this

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indispensability is juxtaposed with the fact that the resulting demand significantly, continuously and unsustainably trumps the available supply. The implication then, is that efficient management of land resources becomes enormously paramount, and this conclusion forms the premise of land administration and management.

The conceptualization of the land administration notion by the United Nations Economic Commission for Europe in 1993 was partly inspired by the work of De Soto on the socioeconomic significance of land titling, culminating in the conceptuality that land administration represents "the process of determining, recording and disseminating information about ownership, value and use of land and its associated resources". A key takeaway from this assertion is the criticality of information to the land administration process which equally deems land information management as an essential obligation.

In the development of their land information management system, Civix defined land information management (LIM) as the "tracking and documentation of data, stakeholder correspondence, and reporting of metrics through all phases of the process". From an empirical standpoint, McLaughlin (1990) in Dale (1991) extrapolates LIM as the "effective use of information in the acquisition, development, use and conservation of land resources" (McLaughlin, 1990 in Dale, 1991). While a perusal of both submissions delineates their similarity and clarity, it also evokes a host of other questions such as – to what end is LIM? In this respect, we argue that a considerable goal of LIM is the ease of referencing associated with availability and accessibility of 'approved information or data'.

Kurwakumire (2014) concurs with this position with the assertion that "to achieve betterment in land management, there is need for accurate, reliable and up-to-date land information." Yet, as easy as it sounds, institutional operationalization of this cogitation presents a cornucopia of systematic and idiosyncratic hindrances that range from infrastructural deficit, rising operational costs, technological and environmental metamorphosis, political interference, customer dissatisfaction amongst others. Morenikeji et al. (2017) decomposed these challenges into difficulties and delays in land title processing, inefficient regulatory requirements as represented by the Nigerian Land Use Act (1978), inadequate application monitoring, coordination and follow-up, erroneous survey plans, poor state of record keeping, and corruption. Persistence of these contorted impetuses by land administration agencies in developing countries, presents a no-brainer to the possibilities of a preponderance of these challenges with demographic expansions.

The World Bank (2007) identifies the criticality of these challenges to economic development in developing countries with the acknowledgement of the essentiality of efficiently managing land information to tenure security, investment, small-holder-based development and poverty reduction. To transform the narrative for developing nations, there is the dire need for the adoption of a number of improvement practices. Nwokike (2019) toes this line with the avowal that "with increasing globalization, the need for digitalization is becoming ever more necessary in every aspect of land administration and information management for reliability, accessibility, currency and accuracy". With the seeming current quagmirical state of affairs, it indeed becomes more evident that the search for a technology that simplifies land information management complexity, and offers a pathway to rapidly accessible, yet tamper-proof information is vital for economic development.

We align this perspective with evidence from developed countries (Elia et al., 2013; Navratil, 2020; Saberi et al., 2019) which suggest a land information management system driven by recent developments in technology, otherwise known as disruptive technologies. Omole et al. (2019) could not have put it better when they presaged that the present business models are becoming obsolete, and there is need for organizations to envision the potentials of disruptive technologies. This has necessitated a rethinking of land information management to integrate innovative strategies for effective, and relatively efficient coordination, synchronization, accountability, responsibility and collaboration of land-related data. One such innovative integration is Blockchain Technology (BT), premised upon an attenuation, if not eradication, of delays, transaction inconsistency, and fraudulent practices such as data altering and falsification through improved information sharing and high-level verifiability.

Blockchain Technology: An Overview

Blockchain is "a peer-to-peer network that leverages upon Internet of Things (IoT) technology to provide a distributed database, comprising records of transactions that are transparently shared among participating parties" (Zhao et al., 2016). In lay terms, this describes a set of data stored independently on several computers, under a single identified protocol that allows for peer-to-peer transactions. The transactions occur when independent input of data is initiated from separate entities within the network. This technology can come in any of 3 categories, comprising the private, public and consortium blockchain, with different suitability for different organizations.

The private blockchain censors all data within the chain from the public and is more close-ended. It uses an administrative node to coordinate transactions within the chain. Data visibility within the chain is only by clearance or authorization granted by the administrative node. Such blockchains operate on Hyperledger platforms (Bryatov & Borodinov, 2019), and is most suited to audit firms or independent accounting or regulatory organizations. In other words, the private blockchain can be employed by land administrators in developing countries in the provision and enforcement of regulatory directives, establishment of landed property business norms, title registrations, in addition to controlling the interface between categories of title, and landowners within the network.

On the other hand, the public blockchain offers all entities within the chain visibility and "consensus-building" access. This is so because there is no administrative node to coordinate transactions, instead transactions are based on a consensus amongst the entities. Bitcoin offers a clear illustration of this category of blockchain technology. This negation of administrative nodes differentiates the public blockchain from the consortium blockchain, though the node is subject to selection by the entities in the network. Entities within the blockchain network for land administration purposes are employees of the land administration agency/ministry, landowners, government oversight members, financial institutions, and other requisite stakeholders. Any criteria of selection can be adopted by these groups, as long as it conforms with majority consent.

Mougayar (2016) pinpoints the inimitable attribute of blockchain to its meta-technological composition of "several other technologies such as software development, cryptographic technology, database technology, and the likes. It is this cryptographic integration in blockchain technology (BT) that distinguishes it from other IoTs. By this, BT refers to a database management system that facilitates data sharing and storage, without the trust issues that usually accompany use of intermediaries in the land registry. Kamble et al (2019) lends credence to this assertion with the avowal that BT is a "peer-to-peer platform which doesn't need any third-party intermediary". Crosby et al (2016) alludes the negation of third parties to "different transaction entities who work as cryptography-validated nodes".

Presenting a vivid expression of this functionality, Pilkington (2016) posits that first, the BT system "records every transaction on a block across multiple copies of the ledger". Secondly, this information is disseminated to every stakeholder in a transparent manner, thereby enhancing visibility within the network. Thirdly, the functionality of the system which allows for a stakeholder to add data to the block by virtue of doing transaction in the network, view available data, but can never modify or hack the data provides the most sufficient evidence of its security physiognomy. This feature is enhanced by a security architecture known as cryptography, which refers to the configuration and encryption of data in such a manner that only those with requisite clearance or approval can decipher its information (Underwood, 2006). With this, it is safe to probably assert that the insecurity protocol of the unencrypted IoT platform is eliminated.

From the foregoing, it may be inferred that this novel technology offers potentials for a resplendent hybrid of accessible, responsive, available, transparent and secure land information management. If so, where lies the shortcomings? We present them in a hybrid of empirical, practical and theoretical context.

1. Adoption Rate

Reminiscences of the Technology Acceptance Model which measures the adoption rate of new technologies in an area, come to mind. The TAM was proposed by Davis in 1985 as a measure of how end users perceive the utility and ease of using a new technology. By this, Davis argues that these perceptions determine the attitude of the end user towards a new technology, and which is a further determinant of the adoption rate of the novel tech. The reference to TAM in this study is premised upon its empirical verification as an "instrument for predicting technology adoption" (Howell, 2016; Larasati & Santosa, 2017; Verma & Sinha, 2018; Xie et al., 2017).

Omole et al. (2019) in a recent study examined the TAM from the perspectives of blockchain technology in Nigeria, and we build our investigation upon their results. From the study, we found an acceptable level of blockchain awareness which was not equally matched by a keenness to immediately adopt the technology. The study reports over 50% awareness level, 100% acceptability, over 95% preparedness, but however forecasts that it will take between 5 to 10 years for the technology to become mainstream. Though similar study specifying peculiarities of land administration is lacking, the insinuated knowledge-action deficit were explained by a compendium of regulatory, personal and economic factors.

With respect to institutional frameworks, Omole et al. (2019) blame the lack of coordinated platforms for BT knowledge acquisition and application, and existing policy frameworks on "inconsistent, confusing, misleading and hazy vocabulary in blockchain technology". What can be gleaned from this assertion is that the blockchain analogy is not yet vivid enough for several practitioners and regulators to fully adopt the technology. Also, on the personal front, there are signals of some skepticism that still exists with respect to its security, especially given the public knowledge of several frauds perpetuated with the cryptocurrency mode of blockchain technology. This skeptical attitude actually resonates with the propositions of another theory, which is the Theory of Reasoned Action developed by Ajzen and Fishbein in 1980. The TRA argues that, "people are more likely to develop intentions (or motivations) if they have a positive attitude towards a subject".

So, from the personal viewpoint, there is a contention that it alludes to low level of technical knowhow about the system, which has also been faulted on the lack of requisite institutional support. This begs the questions, how ready are our institutions for regulating BT adoption? How ready are professionals for BT adoption? We approach the readiness query from the perspective of the Technology Readiness Index, which Parasuraman (2000) defines as, "the construct 'that can be viewed as an overall state of mind resulting from a gestalt of mental enablers and inhibitors that collectively determine a person's predisposition to use new technologies".

Pattansheti et al. (2016) and Larasati et al. (2017) confirm the combination of the TRI theory with TAM as a measure of technology adoption.

Economically though, the skepticism continues with organizations skeptical about the cost requirements of implementing the technology. Actually, the most significant encumbrance to prevalent implementation of BT in supply chains lies in an appreciation of its functionality. This aspect would lead us to the empirical context of the BT overview, in spite of the distinct culpabilities levied on the empirical insufficiency on the financial implications of its adoption. For instance, Omran et al. (2017) conducted a study on the development of a Blockchain-driven supply chain finance framework. Efficiency, transparency, and autonomy were identified as the key value drivers of supply chains. The study also introduced a "BT-based reverse factoring and dynamic discounting system for better decision making". While the effort in developing this financial system is hugely commended, we also reiterate that the framework is still conceptual given the minimality of evidence of its empirical verification and validation in land administration processes.

2. Gap in Literature

From the preceding paragraph, it becomes immediately clear that another challenge of BT integration in land information management is the inadequacy of empirical foundation and direction. Koteska et al. (2017) make the contention that the "efficacy and benefits of a BT investment is yet to be sufficiently proven", while Kamble et al (2019) in agreement presents the exposition that presentation of the benefits and challenges of BT from a general standpoint forms the crux of extant research on the concept. We use the study of Apte&Petrovsky (2016) to illustrate Kamble's (2019) argument. Apte et al. (2016) investigated the "role of BT in excipient supply chain management" and found it useful in "maintaining permanent online transaction records, data security against falsification or fabrication". As Kamble et al (2019) suggested, studies as this only reinforce the cosmetic expositions of BT benefits without practical directives on pathways to attaining such benefits.

Perhaps, in a reprieve for institutional actors, this gap in extant BT literature presents the convenient excuse that low BT adoption rate is more of empirical deficiency than institutional.

Certainly, it is not within the purview of this study to, in any way, query the empirical coverage of BT, the study instead expresses the observation from available literature which shows mostly conceptual scoping of the technology. Amongst the few studies which have gone beyond the narrative to address the applicability and practicality of BT in information management (Kumpajaya and Dhewanto 2015; Folkinshteyn and Lennon 2016), this study joins the few at the fore of channeling the discussion towards land information management in developing nations. Therefore, we contribute to theoretical and practical knowledge with the exposé of relevant BT applications for land administration.

Diffusion of Blockchain Technology in Land Information Management: An Empirical Review

Prior to an analysis of BT applications in land information management, we present a theoretical elucidation of its application in other industries, as a learning fulcrum for BT application in LIM systems. We begin with Wu et al (2017) who confirm the veracity of distributive ledger in enhancing data visibility. The study based this argument on the application of an "online shipment tracking framework" on a blockchain public ledger. They found that this framework eliminated challenges hitherto experienced in independently validating shipment tracking information in traditional networks. In addition to the use of distributive ledgers, Korpela et al. (2017) extended BT supply chain digitalization to successful integrations of cloud-based smart contracts and time stamps. The implication for LIM is that this would enhance the traceability of land information such as category and security of title and owner for search purposes.

Ksheti (2018) extended his BT integration research to the oil and gas industry, approaching his enquiry from a readiness and adoption standpoint by applying the hypotheses of the Innovation Diffusion Theory. Considering "various corporate objectives such as cost, quality, speed, dependability, risk reduction, sustainability, and flexibility", the study found that "industries such as oil trading with many supplier layers will emerge as the front-runner in blockchain adoption". We see that a lot of these studies do not provide in-depth BT application methodology in LIM, instead focusing more on the potentials and benefits. So, what do we learn from these expositions? A presentation of some empirical positions on BT digitalization of LIM is pertinent.

As BT is "expected to speed up processes and guarantee reliability (Kim &Laskowski 2016), the study examines literature on the intricacies of BT integration in data generation, record keeping, contracting, payments, policy planning and implementation, and communication domains of LIM system. This speaks to a blockchain technology precis of speed, security, efficiency and accessibility. With these data management potentials, BT is not just able to track and authenticate data, it is also able to determine the origin of the entry, thereby bringing some form of accountability to the chain. Thus, we aver that any consideration of the application of BT in LIM and their predictor effects on its digitalization, should be astutely preceded with pertinent queries as:

a. How would BT improve existing traditional LIM framework?
b. Would it remove extant LIM challenges?
c. Would it create more problems of its own?
d. Would it interface with already existing LIM digitalization, such as LADM (Land Administration Domain Model), GIS (Geographic Information System).
e. How can it be funded?
f. How can it be regulated?

These queries would not just form the basis of our review and empirical investigation, also, it should form the bedrock of BT designs, evaluations, and adoptions by land information managers with a view to an indigenization of the technology to the industry's peculiarities.

Methodology

The study examined the role of disruptive technologies is engendering sustainable land information management in developing countries, where there are ubiquitous records of unsustainable land administration practices. Indeed, from literature available to the researchers, the study is the first to offer empirical examinations of blockchain applications in land information management system digitalization in Nigeria. Majority of related extant studies in developing countries have been more conceptual, theoretical and without significant emphasis on LIM as an inimitable construct.

The study employed mixed-methods research design which allows for the embedment of compendium of quantitative and qualitative analytical methods in one study. Using Google Form, a self-administered e-questionnaire was designed, validated, pretested (test-retest), and disseminated to the sampling frame. The sampling frame consists of land information management staff of Registries and Ministries of Lands across Nigeria. Given the infinite physiognomies of the study population as a result of official confidentiality, the sample size was determined using Freund and Williams formula as follows:

Equation I: $n = \underline{Z^2pq}$

Where:

n	=	sample size
p	=	percentage of positive response (0.8)
q	=	percentage of negative response (0.2)
e	=	margin of error
Z	=	level of confidence (1.96) indicating a 95% rate

The researchers, by virtue of experience, share same and similar professional networks with the unit of analysis (LIM staff); which further informed the confidence level of 95%. This was equally validated by a pilot survey on the unit of analysis, which generated result of p (0.7) and the q (0.3), at α =0.05 (margin of error). Thus, we have:

$$n = \frac{(1.96)^2\,(0.7)(.3)}{(.05)^2} = \frac{3.8416(0.21)}{.0025} = \frac{.806736}{.0025}$$

322.69, *approximately* 323

Hence, the sample size of the study is 323 LIM staff.

Using snowballing technique, the e-questionnaire link was sent through WhatsApp and Telegram to the respondents on the Nigerian Institution of Estate Surveyors and Valuers, Nigerian Institution of Surveyors, Nigerian Institute of Town Planners platforms, in addition to other staff of the

Ministries through their designated online platforms. This mode of dissemination was informed by the knowledge that these platforms offer a national coordination of these practitioners, thereby enhancing the ease of accessibility to respondents. Questionnaire return rate was 85.76%, and having surpassed the 65% acceptable rate for questionnaires (Kelley et al, 2003 in Ewurum et al., 2020), it was considered valid.

Data was analyzed quantitatively using One-Sample T-Test at a significance of 5%, with a view to ascertaining the extent to which observed data deviated from the universal mean. The qualitative facet of the study followed a Tailored Meta-Analysis to correlate prevalent blockchain empiricisms with our applicable blockchain for LIM region. This laid the grounds for Glass's Delta analysis to extricate the dominant blockchain application themes for LIM. This expressed as follows:

Equation II: Glass's Delta ($D = M_1 - M_2 / S_{Control}$)

The Google Forms disseminated to respondents contained vivid of elucidations of Blockchain applications relevant to LIM, with a view to apprising them of the potentials of the technology as informed by extant literature on the technology. This analysis informed the results, discussion and conclusion of the study.

Results:

The following null hypotheses were formulated in consistency with the research questions, and the consequent outcome of the analysis presented the following Tables:

Ho1: Primary blockchain would not provide accurate, unalterable and accessible land information.

Ho2: Blockchain would not attenuate data loss and enhance responsiveness.

Ho3: Blockchain would not create economic and legal problems for LIM in Nigeria.

Ho4: Blockchain would not seamlessly interface with already existing LIM digitalization, such as LADM (Land Administration Domain Model) and GIS (Geographic Information System).

Ho5: Blockchain cannot be effectively funded through tax-oriented public-private partnership arrangements.

Ho6: It cannot be regulated through effective institutional and legislative oversight.

Table 1: Descriptive Statistics on Implications of Blockchain in Land Information Management

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skeweness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Ho1: Accurate, unalterable, accessible information	277	2.00	5.00	4.1913	.71945	-.656	.146	.346	.292
Ho2: Attenuate data loss, enhance responsiveness	277	1.00	5.00	4.1300	.87087	-.786	.146	.229	.292
Ho3: Create economic and legal problems	277	2.00	5.00	4.2852	.66613	-.546	.146	-.065	.292
Ho4: Seamlessly interface with existing digital frameworks	277	1.00	5.00	4.2383	.75727	-.730	.146	.323	.292
Ho5: Can be effectively funded via PPP	277	1.00	5.00	3.1155	1.55608	-.246	.146	-1.500	.292
Ho6: Can be easily regulated	277	1.00	5.00	1.9422	.80099	.659	.146	.564	.292
Valid N (listwise)	277								

Source: IBM SPSS Statistics 22 (2020).

Table 1 is the descriptive analysis of blockchain implications to land information management in Nigeria, as indicated by the means, standard deviation, skewness and kurtosis. The results were further subjected to One-sample T-Test Analysis on SPSS Version 22 (Table 2) for further clarity and robustness.

Table 2: One-Sample T-Test

One-Sample T-Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Ho1	96.960	276	.000	4.19134	4.1062	4.2764
Ho2	78.929	276	.000	4.12996	4.0270	4.2330
Ho3	107.066	276	.000	4.28520	4.2064	4.3640
Ho4	93.149	276	.000	4.23827	4.1487	4.3278
Ho5	33.323	276	.000	3.11552	2.9315	3.2996
Ho6	40.357	276	.000	1.94224	1.8475	2.0370

Source: SPSS, Version 22

The result of the analysis in Table 2 shows that with p-values of <.05, the null hypotheses was rejected. Thus, it can be observed that blockchain would predict accurate, unalterable and accessible land and titling information ($t=96.960$; $p<0.05$); attenuate data loss, save time and enhance responsiveness ($t=78.929$; $p<0.05$); and seamlessly interface with existing technologies such as GIS and LADM ($t=93.149$; $p<0.05$). On the downside, the result of $t=107.066$ and p-value of less than .05, indicate that blockchain would create economic and legal problems in land administration, and this result coincides with the t outputs of 33.323 and 40.357 on the ease of funding and regulating the network respectively in Nigeria.

Table 3 displays the qualitative analysis results as follows:

Table 3: Blockchain Applications in Land Information Management

Processes	Blockchain Capability	Compatibility
Data generation – title and deed registration	Private blockchains regulate participant (landowner) registration, thereby sustaining the integrity of the registry Uses administrative nodes and unique identifier with validated contributed information to bar imposter encroachment	Yes
Information Recording and Tracing	Land information are registered as linked "blocks" and are mapped and recorded as a chronological "chain." Keeps track of a multitude of information and transactions entered by a multitude of stakeholders through data management efficiency. Enables registry and land information management officers to provide tracing information in shared ledger	Yes
Documents Verification	Blockchain-enabled closed ledger system helps in developing the much-needed trust between the registry and real estate investors; BlockRx token enables information dissemination only to "trusted participants", thereby securing investor data	Yes
Information	Creates shared system for relevant land-based information dissemination to stakeholders using distributed ledger system. Smart contracts built into the chain define trusted parties and levels of data access, but beyond that, without the BlockRx token, there is no access.	Yes
Payments	Uses the BlockRx™ Token by iSolve to track inconsistent financial activities Offers financial security through the use of cryptography, such as the BlockRx™ Token by iSolve	Yes

Regulation	Utilizes private blockchain essentials such as administrative nodes to regulate registry and land information-based practices within the network. All stakeholders have access to information based on different levels of restricted influence. This prevents data alteration and falsification	Yes

Conclusion

Blockchain technology utilizes a peer-to-peer network system for the creation of smart contracts, recording, tracking and sharing of immutable and transparent information with stakeholders within the network. This assertion is leveraged on its benefits of verifiable, transparent, visible, traceable and secure information management capabilities, with positive externalities of guaranteed land information documentation and security. The security apparatus of BT rests on the impossibility of cyberattack on blockchains' decentralized structures and encryption algorithms. This is premised on the fact that "information are permanently time-stamped and stored, thus implying that attackers would need to reverse a blockchain's entire history while under the scrutiny of all users" (Tapscott and Tapscott 2016). This is virtually implausible at the moment.

This technology also has the land administration merits of providing the infrastructure necessary for real estate investors and registry organizations across the chain to conduct online transactions without the typical use, delays and cost of middlemen, as ubiquitously obtains at present. On the downside, due to the low diffusion of this technology, it may come at a rather higher cost for early adopters as shown by the findings of the study. At present, the cost remains unregulated, and this may portend higher cost outlay now that there are relatively few BT vendors in the country, until scaled adoption occurs. As a result, it may be difficult to evaluate the actual performance of BT investment in the short-term. This leaves the door ajar for further research on the discourse.

Recommendations

The study recommends the composition of a committee to examine on a larger scale the intricacies of blockchain as per subsequent diffusion in land information management. This investigation would provide a pilot survey for subsequent formulation and enactment of legislative and statutory frameworks that guide the adoption in land registries. There should be more public education on the pros and cons of adopting the technology with a view to positioning stakeholders for seamless adoption of the technology. Such awareness creation, it is believed, would improve chances of funding by private enterprises.

Research Agenda

The study has shown the different phases where blockchain can be applied to land information management. However, what is not yet known and established is the extent to which the technology is known and accepted by land registry staff in developing countries. Filling this empirical lacuna would significantly direct strategies for scaled adoption of the technology in the real estate industry

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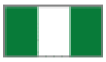

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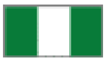

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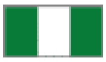

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