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Developing a policy framework for adoption and management of drones for agriculture in Africa

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ABSTRACT

This paper proposes a drone policy framework for developing drone regulations for Africa, expediting the individual countries' developing drone regulations. This research was conducted following concerns raised by individuals and businesses whose imported drones were seized by customs or had to go through a cumbersome process for approval to use drones for lack of regulations. To derive the policy framework, we matched the provisions of 15 existing drone regulations from Africa to the International Civil Aviation Organization (ICAO) Manual on Remotely Piloted Aircraft Systems (RPAS) using a decomposition modelling technique. The proposed framework is presented as a formal business process model and is evaluated in a multi-case study approach in two different case studies. The results indicate that two key aspects/elements are crucial in the development of a drone framework and thus are included in our framework: (i) stakeholders' inclusion in the policy development and (ii) regulators liaising with security agencies like the police and immigration officials to implement and enforce developed regulations. Applying the proposed framework in describing existing regulations reveals that 40-85% of provisions in existing regulations conform to the provisions in ICAO's RPAS manual.

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Drones; business processing modelling notation; International Civil Aviation Organization; policy framework

1. Introduction

The introduction and advancements of technologies in the agriculture sector are increasing exponentially (Luppicini and So 2016), while the regulatory processes to govern these technologies are lagging (Rao, Gopi, and Maione 2016). Drone technology promises to foster innovations that will disrupt existing industries (Giones and Brem 2017) by providing products and services (Beninger and Robson 2020).

Drones have a global market estimated to be $2 billion in 2016 to grow to nearly $127 billion in 2020 (Moskwa 2016 as cited in Giones and Brem 2017), reflecting the broad applicability of drones in the business sectors of agriculture, health, mining, and infrastructure to support tasks such as surveying, humanitarian work, disaster risk management, and research.

Regulatory processes for both commercial and private use of drone technologies are delayed due to the open-source development of the technology, making it difficult to keep track of changes in the

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technology (Rao, Gopi, and Maione 2016). Being open-source technology that can flexibly reconfigure makes it challenging to develop policies and tools to support implementation (Allenby and Fink 2005). Regulators, therefore, rely heavily on the tacit knowledge of those who build them (Downer 2010) and to know about the nature and performance of the technology (Spinardi 2016).

Agriculture plays a significant role in the overall global socio-economic fabric and its role in the African continent is even more prominent (Tiwari and Dixit 2015). Adopting drones for agriculture could generate job opportunities for the youth and improve agricultural production (Sylvester 2018). Drones in agriculture are typically used to obtain real-time imagery and sensor data from farm fields minimising the need to physically go through the fields, enabling yield increase and reduced farm cost (Malveaux, Hall, and Price 2014; Tiwari and Dixit 2015).

On the flip side, a drone's components during flights can fail to result in a crash that may harm people or damage property (Clarke and Moses 2014). The growth of drones in domestic use has raised public concerns regarding safety and privacy issues (Luppicini and So 2016). (Nelson and Gorichanaz 2019) indicated that residents reported seeing drones hovering around their windows and backyards which calls into question an individual's right to privacy as drones become more prevalent. Notwithstanding the above-stated concerns, the application of drones in the agriculture sector is seen as one of the fastest-growing areas (Watkins et al. 2020), while the regulatory responses from the National Civil Aviation Authorities (NCAAs) in Africa are slow. Regulations are in place in some African countries; others are either grappling with policy creation and implementation or do not have regulations in place (Jeanneret and Rambaldi 2016). A framework that captures the tacit knowledge about drones and guides regulators in Africa, who often have limited resources, is essential. Therefore, the purpose of this paper is to develop a policy framework that could help drive country-specific drone regulations. Drawing from the design science research (DSR) approach, the research questions (RQs) to be addressed are;

RQ1. What policy framework could help developing countries derive their specific drone regulations?

Once we have presented the policy framework, we will further address the following research questions:

RQ2. How practical is applying the developed policy framework in describing an existing drone regulation of a country?

RQ3. How practical is applying the developed policy framework for developing a new drone regulation for a country?

This paper's remainder is structured as follows: theoretical background in section 2 and the research methodology in section 3. The results and discussion are presented in section 4. Finally, section 5 concludes the paper.

2. Theoretical background

2.1. Drones in agriculture

The usage of drone technology within the last decade is increasing especially in the agriculture sector (Hogan et al. 2017). Unmanned aerial vehicles (UAVs) commonly known as drones are remotely controlled by an operator on the ground or pre-programmed to fly specific routes (Nelson and Gorichanaz 2019). (ICAO 2015) manual on RPAS defines the following terms:

(i) Remotely piloted aircraft (RPA). An unmanned aircraft piloted from a remote pilot station.
(ii) Remotely piloted aircraft system (RPAS). A remotely piloted aircraft, its associated remote pilot station(s), the required command and control links, and any other components as specified in the type design.

The terms UAVs, RPA, and RPAS will be referred to as stated in the source papers but the term drone(s) will simply be used throughout this paper.

Drones have been successfully applied in agriculture, energy, mining, infrastructure, and transportation (Kasim 2018). Drone technology is an essential tool and could provide usual information for farmers in arable farming and animal husbandry. Drones in agriculture were initially used for chemical spraying as the solution to visibility problems due to cloudy weather or inaccessibility to a field of tall crops (Simelli and Tsagaris 2015). Recently, (Huuskonen and Oksanen 2018) demonstrated the use of drones in sampling soil, while (Tu et al. 2020) dealt with measuring horticultural tree crop structure using drones. The use of drones now extends to surveying crocodiles and other animal populations in the wild (Ezat, Fritsch, and Downs 2018) with the potential to revolutionise how animals and habitats are monitored (Scarpa and Piña 2019).

Drones may become an essential tool in precision agriculture to improve agricultural management strategies concerning fertiliser or pesticide application (Michels, von Hobe, and Musshoff 2020; Kim, Park, and Lee 2018; Schmale Iii, Dingus, and Reinholtz 2008). According to (Clarke and Moses 2014), the application of drones in civilian contexts creates the prospect of a wide range of benefits. Some of the benefits of using drones in agriculture in Africa are presented in the 'The Digitalisation of African Agriculture Report 2018–2019' by (Tsan et al. 2019). Drones could attract educated youths to venture into agricultural service enterprises and improve agricultural production and farmers' returns on investment (Sylvester 2018). These improvements are fundamental elements of development in society (Coccia 2019a). Africa could be the breeding ground of new technologies that will revolutionise services for broad masses (Rodrik 2018), improve living standards and reduce poverty (Aghion et al. 1998 as cited in Coccia 2010).

2.2. Research and development (R&D) for technological innovation

Research on social acceptance and regulatory implications of drones is lacking (Nelson and Gorichanaz 2019). The study of (Soesilo and Rambaldi 2018) on perceptions and applications of drones in agriculture in African, Caribbean, and Pacific countries indicated that 85% viewed drones in agriculture favourably. R&D investments show the efforts nations put into science advances and new technology achievements to take advantage of essential opportunities in markets (Coccia 2019b). Firms can achieve the prospect of a temporary profit monopoly in markets through technological dynamism (Coccia 2017). When market forces drive technological development, the path of technology change can be modified (Ruttan 1997). Support for firms' innovation strategy is needed on critical decisions regarding when to invest in R&D of new technologies, abandon the old or pursue an intermediate level of R&D investment between old and new technology for fostering technological advances (Coccia 2015; Coccia and Watts 2020). On the flip side, (Stöcker et al. 2017) indicated that, current legal frameworks that regulate UAVs present significant barriers to R&D of the technology.

2.3. Regulating drone use

In recent years, drones' illegal use could result in additional regulations and restrictions (Watkins et al. 2020). UAVs are new airspace objects that pose a potential risk to other users of the airspace and third parties on the ground (Stöcker et al. 2017). Therefore, a growing number of countries are therefore establishing regulations to minimise the risk as drone flights not controlled pose a threat to air navigation and transport (Tobór, Barcik, and Czech 2017). In keeping citizens' safety and privacy rights secured, regulatory regimes are necessary for realising the full potential of drones (Greenwood 2016).

The Technical Centre for Agricultural and Rural Cooperation ACP-EU (CTA) started a project in 2016 and trained 38 young entrepreneurs across 21 Africa countries and supported them financially in offering drone-based services to farmers' organisations, agribusinesses, government, international development agencies, and other parties. Some of these entrepreneurs raised concerns about how their imported drones were seized by customs or had to go through a cumbersome process for approval to use drones for lack of regulations. It is in this regard that this research was conducted.

Formal regulations are customarily implemented as laws, and drones operating in controlled airspace are subject to formal regulations, as are other types of aircraft (Clarke and Moses 2014). Aviation provides an environment that is almost uniquely unforgiving of mistakes (Cook and Charles 1997), and when it comes to international standards, ICAO acts as a focal point in terms of the need for harmonisation of terms, strategies, and principles about the development of a regulatory framework for drones globally (ICAO 2011). (Figure 1) outlines the civil aviation regulatory hierarchy in the context of Africa.

ICAO is a United Nations (UN) specialised agency that works with its member states and industry groups to reach consensus on international civil aviation Standards and Recommended Practices (SARPs) and policies in support of a safe, efficient, secure, economically sustainable, and environmentally responsible civil aviation sector globally. Individual countries may apply rules about drones different from the SARPs, but they must file those rules with ICAO (Clarke and Moses 2014). The implication for filing could be to allow ICAO to ascertain what is applicable in each member state. A country has not filed could mean that:

- the country has not yet considered developing a drone regulation,
- the country has considered developing a drone regulation but it lacks skilled personnel and hence delayed the regulation, or
- the country considers drone regulation as a sovereignty issue and does not wish to comply with ICAO's provisions.

ICAO's arrangements are slow so another harmonisation group called Joint Authorities for Rulemaking on Unmanned Systems (JARUS) was formed in 2012 to recommend a single set of technical, safety, and operational requirements for all aspects linked to the safe operation of a UAS (Clarke and Moses 2014). UAS (Unmanned Aircraft System) includes the unmanned aircraft and the equipment that controls it remotely.

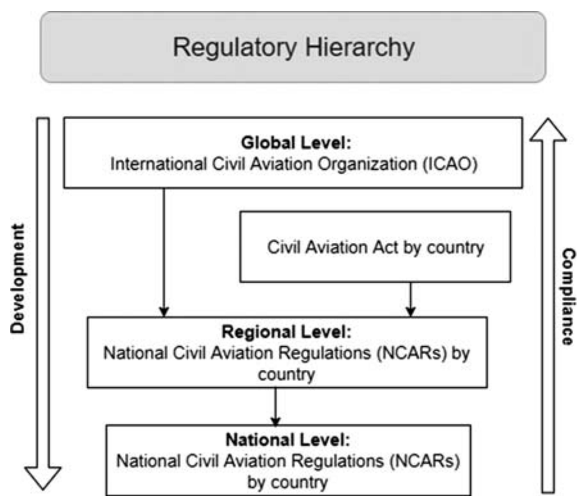

Figure 1. Civil aviation regulatory hierarchy. Adopted and modified from the South African civil aviation RPAS (part 101) regulations workshops, p.3.

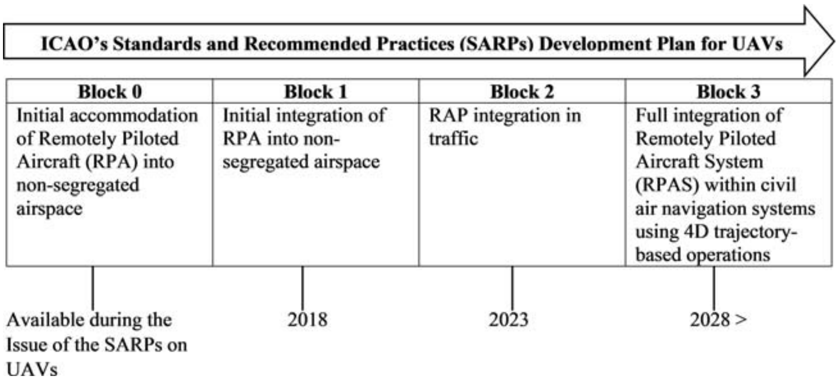

Figure 2. ICAO's Standards and Recommended Practices (SARPs) Development Plan for UAVs. Adopted and modified from the South African civil aviation RPAS (part 101) regulations workshops, p.4.

At the regional level, for example in Europe, we have the European Union (EU) which provides legislations for its member states. Each country has national regulators, but they are bound to base their regulations on EU regulations. This instance is not the case with the Africa Union (AU) where regulation of civilian airspace is the responsibility of the NCAAs in each country. Rules and regulations that apply to drones are issued by the NCAAs and differ widely across African countries (NEPAD 2018). Support from the AU to its member states regarding emerging technologies in the agriculture sector is the issuing of decision 987 published by NEPAD in 2018, which is fundamentally a continent-wide document on drone technology for agriculture and is available in 23 languages. The regulations framework from the NCAAs is primarily based on ICAOs SARPs and states are invited to inform ICAO of non-compliance. (Figure 2).

2.4. Conceptual framework for policy development

Stakeholders are mostly left out in the compiling and discussion of local regulations (Hutahaean 2016). When stakeholders are involved in developing drone policies, they can communicate their goals, objectives, and preferences to the policymakers who must then decide on the policies to be adopted (Walker et al. 2003). The policy process is not straightforward but often iterating because, in practice, the involvement of policy analysts, stakeholders, and policymakers in the process can take different forms (Walker et al. 2003), considering that policy issues are interconnected (Benson and Jordan 2015). There is no standardised process for developing a policy as the iterative process involving adopting policies across several different nations, and subsequent adaptations within individual nations illustrate the prevalence of policy transfer (Dolowitz and Marsh 2000). Policy transfer is 'a process in which knowledge about policies, administrative arrangements, and institutions in one time and or place is used in the development of policies, administrative arrangements and institutions in another time and or place' (Dolowitz and Marsh 1996).

Developing drone regulations, we have developed a conceptual model (Figure 3) for the policy development process to involve policy agents who develop the regulation document.

The policy agents can employ policy transfer in the development process or adopt provisions from an established framework. Therefore, technology assessment aims to inform policy-making or to involve stakeholders at different stages of technology governance through participatory approaches (Kellermann, Biehle, and Fischer 2020). The policy agent or an independent body will be responsible for implementing the policy. Regulations that support the safe use of drones in the agriculture sector will help farmers ameliorate their lack of information and communication technologies (ICTs) for agricultural development and limited advisory services (Aker and Mbiti 2010). Therefore, we are proposing a drone policy framework for Africa to support the AU effort in

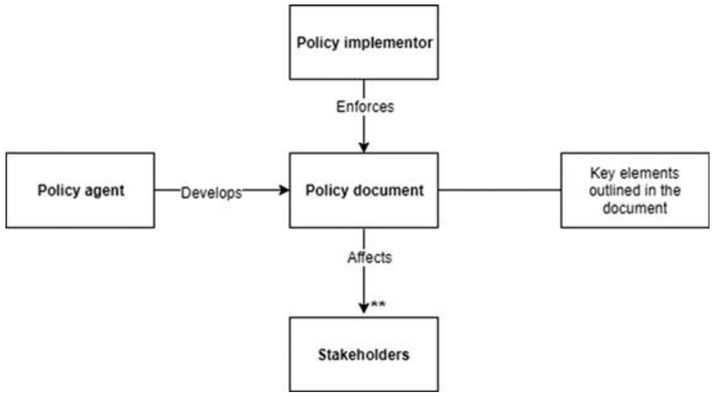

Figure 3. Conceptual model for policy development.

exploiting the promises of drone technologies in the African continent. A new drone policy framework for Africa is needed because the regulatory frameworks adopted elsewhere, in Europe or North America, might not be suitable for African countries considering the extent and context of drone usage.

3. Research methodology

3.1. Sample

We retrieved drone-related regulatory documents from 15 African countries. The search was conducted from September to October 2018 through the following online sources:

- www.rpas-regulations.com (world's largest online repository dedicated to UAS/RPAS/drone-related regulatory matters)
- www.droneregulations.info (collaborative wiki: Global UAV Regulations Database)
- Google search (Provided some regulatory documents for some countries which were not found in the other databases).
- Some of the civil aviation authorities' websites

The sources either provided a link to the regulatory documents or outlined the guidelines set out by a country to govern drone use.

3.2. Measure

Using ICAO's manual on RPAS as a benchmark, we mapped the current regulatory documents retrieved to the manual. We identified, defined, and instantiated three provisions; conforming, absent, and deviation provisions based on the outcome of the mapping.

A **conforming provision** is a provision adopted from ICAO's manual on RPAS (referenced model) and present in the concrete drone regulation of a country.

An **absent provision** is a provision found in the referenced model but not present in the drone regulation of a country.

A **deviation provision** is a provision not found in the referenced model but is present in the drone regulation of a country.

The policy framework is proposed to include the adoption of provisions (conforming provisions) from the manual. Also, countries could define their provisions (deviation provisions) if adopting provisions from the manual is not sufficient.

3.3. Data analysis procedure

Following the DSR methodology proposed by (Hevner and Chatterjee 2010), we developed our policy framework. According to them, 'DSR is a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artefacts, thereby contributing new knowledge to the body of scientific evidence' (5). The most visible output of the design research tradition is the artefacts (Purao 2002). An artefact is used to describe something artificial instead of something that occurs naturally (Simon 1996). In the book of (Hevner and Chatterjee 2010), abstractions and representations are definitions of information technology (IT) artefacts which we mainly relied on in this paper. The manual on RPAS is represented as a decomposition view (Figure 4) following the decomposition modelling technique from the software architecture design approach (which is a domain of DSR). Decomposition deals with breaking a complex system into parts that are easier to conceive, understand, programme, and maintain. Each provision of the manual is then expressed as a unit of decomposition of the manual and after that, we mapped the existing drone regulations retrieved to the decomposed manual. We established the proposed policy framework as a flow chart following the business process modelling notation (BPMN) method, which is then evaluated as part of the steps indicated in the design science (DS) roadmap by (Alturki, Gable, and Bandara 2011). (Table 1).

After establishing the proposed policy framework, we employed multi-case study research to evaluate it. (Figure 5).

Yin (2018) indicates that, case study investigates a contemporary phenomenon within a real-life context, especially when there is no evidence between the phenomenon and context. In this regard, the framework discussed by (Runeson and Höst 2009) for conducting and reporting a case study is

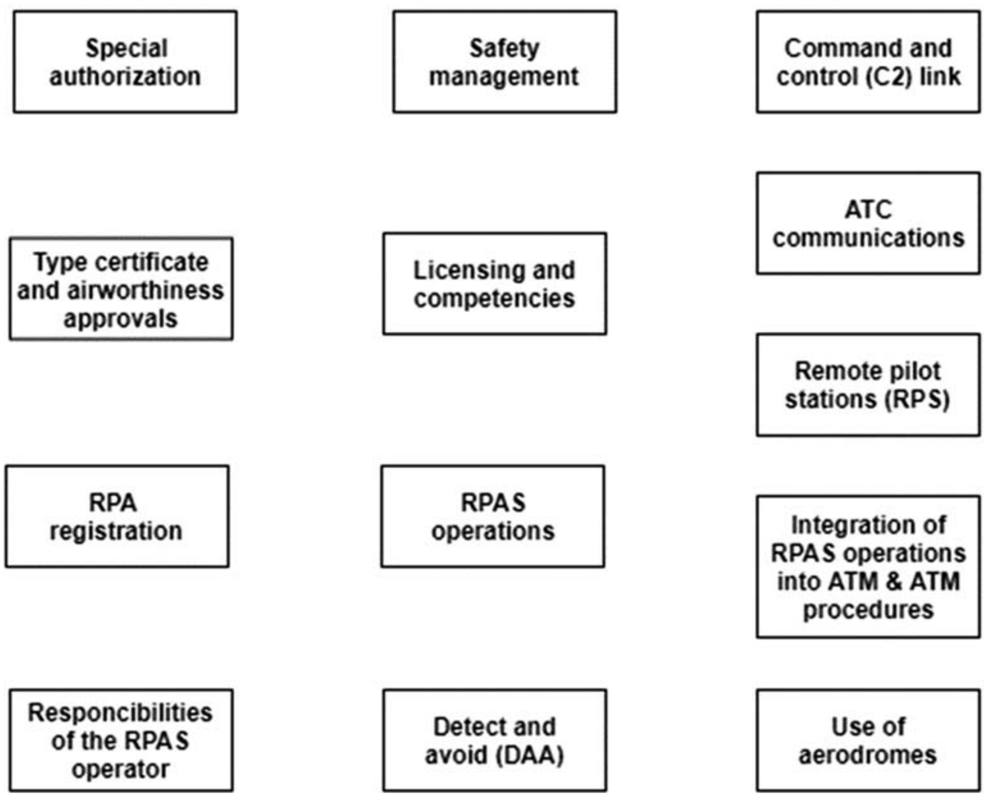

Figure 4. Decomposition view of the manual on RPAS from ICAO (the reference model).

Table 1. Description of the provisions of the referenced model.

Provision	Description
Special Authorisation (SA)	All unmanned aircrafts intending to operate over the territory of another state must obtain special authorisation from that state.
Type Certification and Airworthiness Approvals (TCAA)	Issuing a document by a contracting state to define the design of aircraft types and to certify that the designs meet the appropriate airworthiness requirements of that state.
RPA Registration (RPA-R)	All unmanned aircraft must be registered and obtain a registration mark(s) which shall be located on it for identification and differentiation from model aircraft.
Responsibilities of the RPAS operator (RESRO)	Frameworks and roles on the responsibility of an operator of an unmanned aircraft operate within the confines of the regulations.
Safety Management (SM)	Provisions regarding safety management by state aviation organisations concerning RPAS.
Licensing and Competencies (LC)	Individuals who operate RPAS will have to show that their knowledge, skills, and attitude are relevant for the types of operations.
RPAS operations (RPAS-O)	Provisions of procedures for RPAS flight operations must be observed, which is intended to mitigate risk to persons and property on the ground and other airspace users.
Detect and Avoid (DAA)	The capability to see or detect conflicting traffic or other hazards and take the appropriate action.
Command and Control (C2) link (C2-link)	The data link between the remotely piloted aircraft (RPA) and the remote pilot station (RPS) to manage the flight.
ATC Communication (AC)	Provisions for RPAS to meet the Air-Traffic-Control communications requirements.
Remote Pilot Station (RPS)	This refers to the component of the remotely piloted aircraft system containing the equipment used to pilot the remotely piloted aircraft.
Integration of RPAS operations into ATM and ATM procedures (INT-RPAS)	Provisions on how to safely introduce RPAS operations into the air navigation system.
Use of Aerodromes (UA)	Indicating how regardless of the location of the RPS, the remote pilot will have to identify, in real-time the physical layout of the aerodrome and associated equipment to manoeuvre the aircraft safely and correctly.

adopted and followed. The steps we followed are (1) case study design (2) preparation for data collection (3) execution with data collection on the studied case (4) analysis of collected data (5) reporting. The first two steps are discussed below. The last three steps are discussed in Section 4.

Two different case studies are considered for the overall case study design concerning the evaluation of our proposed policy framework. Using (Figure 4), we evaluated the instance of describing

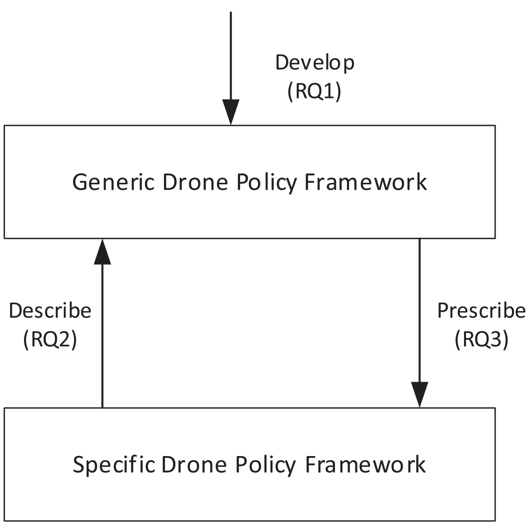

Figure 5. Outline of how research questions will be answered.

existing drone regulations from Ghana, Zambia, and Malawi indicating the conforming, absent, and deviation provisions. The conforming, absent, and deviation provisions for the remaining countries are also presented in a table to constitute the first case study. (Figure 4) is also used to evaluate the instance of developing a new drone regulation for Uganda to constitute the second case study. (Table 2).

Data collection for the case of describing an existing regulation was organised as follows:

(1) The regulatory or policy documents, other related documents, and papers are collected first concerning the case study from the selected countries.
(2) Secondly, the provisions in the documents are extracted and referenced with (Figure 4).
(3) Next step, the decision is made to present the extracted provisions in a decomposition view, and descriptive analysis is made.

Data collection for developing a new policy case was organised as follows:

(1) First, a semi-structured questionnaire is developed using Google forms and sent to a stakeholder in a country without drone policy via email.
(2) Secondly, the framework proposed was followed and the provisions from the answered questionnaire extracted. Conforming provisions and deviation provisions are identified.
(3) Next step, the decision is made to present the new provisions for the country in a decomposition view, and descriptive analysis is made.

4. Results and discussion

4.1. The proposed policy framework

The proposed policy framework is presented in (Figure 6). We proposed that the NCAAs of various countries in Africa be the policy agent. They could start the policy development by first involving relevant stakeholders to deliberate and develop the right provisions necessary and suitable in the country's aviation rules and systems. Relevant stakeholders would serve the interest of their community (Hutahaean 2016) and help define or adopt adequate provisions preventing the calling off established regulations when the provisions are inadequate to address drone-related matters. Also, provisions from (Table 1) can be adopted before defining country-specific provisions as existing regulations largely contain provisions conforming to (Table 1). After adopting and defining provisions, countries are expected to file the provisions with ICAO. This is necessary because it would help ICAO in the global drone policy framework development and the consideration of what is applicable in each member state. After this stage,

Table 2. Case study design.

Case Study Design Activity	Describing an existing drone regulation (RQ2)	Developing a new drone regulation (RQ3)
Goal	Analyse the effectiveness of the method by evaluating the approach of describing a concrete regulation model using the proposed framework.	Analyse the effectiveness of the method by evaluating the approach of developing a concrete regulation model using the proposed framework
Research Questions	RQ2 – How practical is the application of the framework in describing an existing drone regulation of a country?	RQ3. How practical is the application of the framework for developing a new drone regulation for a country?
Background and Source	Official regulation documents and papers	Key stakeholders in drone regulation development
Data Collection	Indirect data collection using document analysis	Direct data collection through semi-structured interviews (mix of open and closed questions)
Data Analysis	Qualitative descriptive analysis	Qualitative descriptive analysis

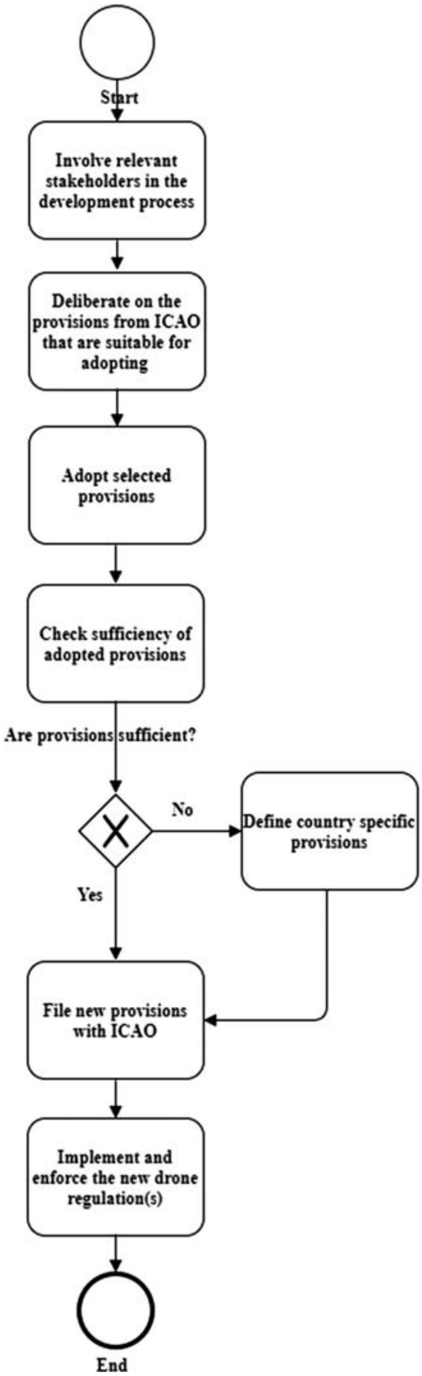

Figure 6. The proposed policy framework.

implementation and enforcement of the regulations are needed by which the public and potential drone users could be made aware of the developed regulations and privacy rules. Awareness could be done using television advertisements, radio, and the internet (social media platforms).

4.2. Implications of the framework

When it comes to regulating drone use in Africa, one issue is the presence or the absence of drone regulations. A second (more important) issue is whether existing regulations are enabling or disabling. All provisions in (Figure 4) are meant for ICAO's member states to determine what is mandatory for them depending on the class of drones considered for use. However, the heterogeneity of various countries' regulations has some common mandatory provisions which include; drone registration, pilot licensing and competencies, permit issuance, and safety management.

A country can adopt a policy from another by considering the context and structures in their country and duly involve relevant stakeholders to prevent calling back of published regulations. Kenya is an example that called back its drone regulation to allow deliberations for amendments due to high tariffs from importing drones at the time of this study. Therefore, involving relevant stakeholders would help policymakers when they fumble around for solutions in the context of great uncertainty and many internal and external constraints (Benson and Jordan 2015). Implementation and enforcement of regulations could become a challenge if governments' willingness is not a key factor. The security agents mandated to enforce regulations need adequate resources to control the misuse of drones. At this stage, sanctions can be provided in the case of non-compliance.

4.3. Describing an existing drone regulation

The various provisions of Ghana drone regulation are presented in (Figure 7).

The Ghana policy document contains 11 conforming provisions representing about 85% of the provisions in (Table 1), one absent provision, and one deviation provision. The deviation provision – issuance of a permit is found to be a stand-alone provision when compared to the special authorisation (SA), type certification and airworthiness approvals (TCAA), and licensing and competencies (LC) provisions. The permit can be obtained from the national security agency. In addition to the directive of this provision, one must obtain written permission from the police in the region where drone flights will occur.

One can match the various provisions in the current regulatory documents to that of (Figure 4). Additional provisions not found in (Table 1) can be identified as well. However, stakeholders' involvement could not be identified in the various documents.

The Zambia drone regulation is presented in (Figure 8) and Malawi drone regulation is presented in (Figure 9).

Unlike the Ghana regulation or others, the Zambia regulation contains no deviation provision but rather, 8 conforming provisions representing about 62% of the provisions in (Table 1). Moreover, like the Malawi regulation, the maintenance (MTN) provision is a stand-alone provision separated from the safety management (SM) provision. The Malawi regulation contains 7 provisions that conform to the provisions in (Table 1) representing about 54% of the reference provisions. There is one deviating provision and the remaining provisions are absent. The maintenance (MTN) provision is also separated as a stand-alone compared to the Ghana regulation, where it is an aspect of the safety management provision. (Table 3).

The remaining regulatory documents retrieved present some confirming, absent, and deviation provisions to (Table 1).

4.4. Developing a new drone regulation

An identified stakeholder involved in the development of Uganda's drone regulation was contacted and we prepared an online survey with Google forms and sent for responses. We extracted information on whether provisions are been adopted from (Table 1) or country defined provisions. Each provision adopted from (Table 1) and those defined by country regulators had a given reason for inclusion into the new drone regulation. At least the stakeholder's involvement would serve and guide the regulators to consider relevant aspects of the use of drones in Uganda,

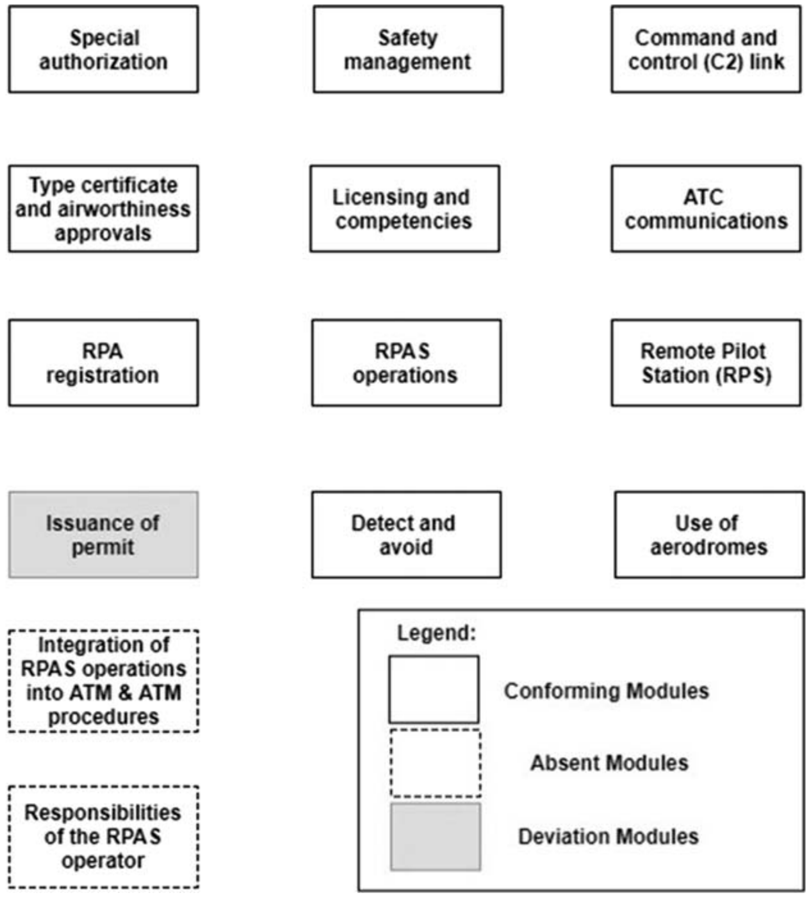

Figure 7. Decomposition view of Ghana's drone regulation.

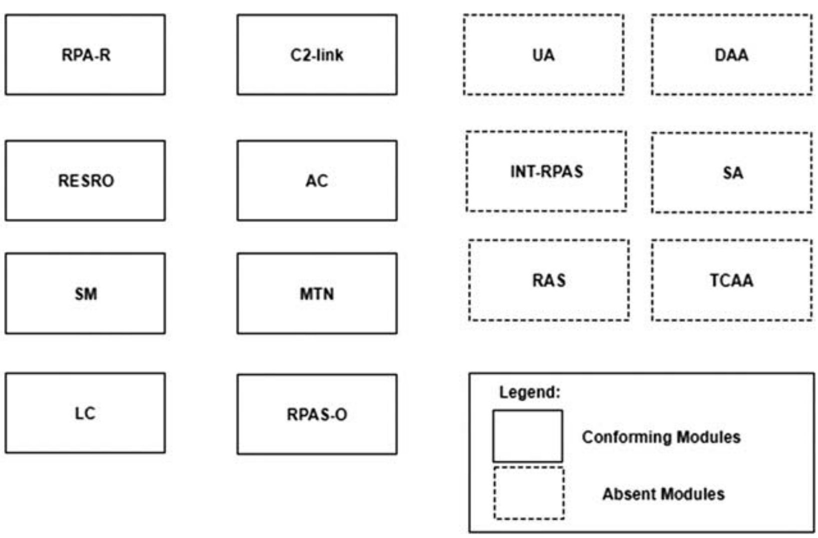

Figure 8. Decomposition view of Zambia's drone regulation.

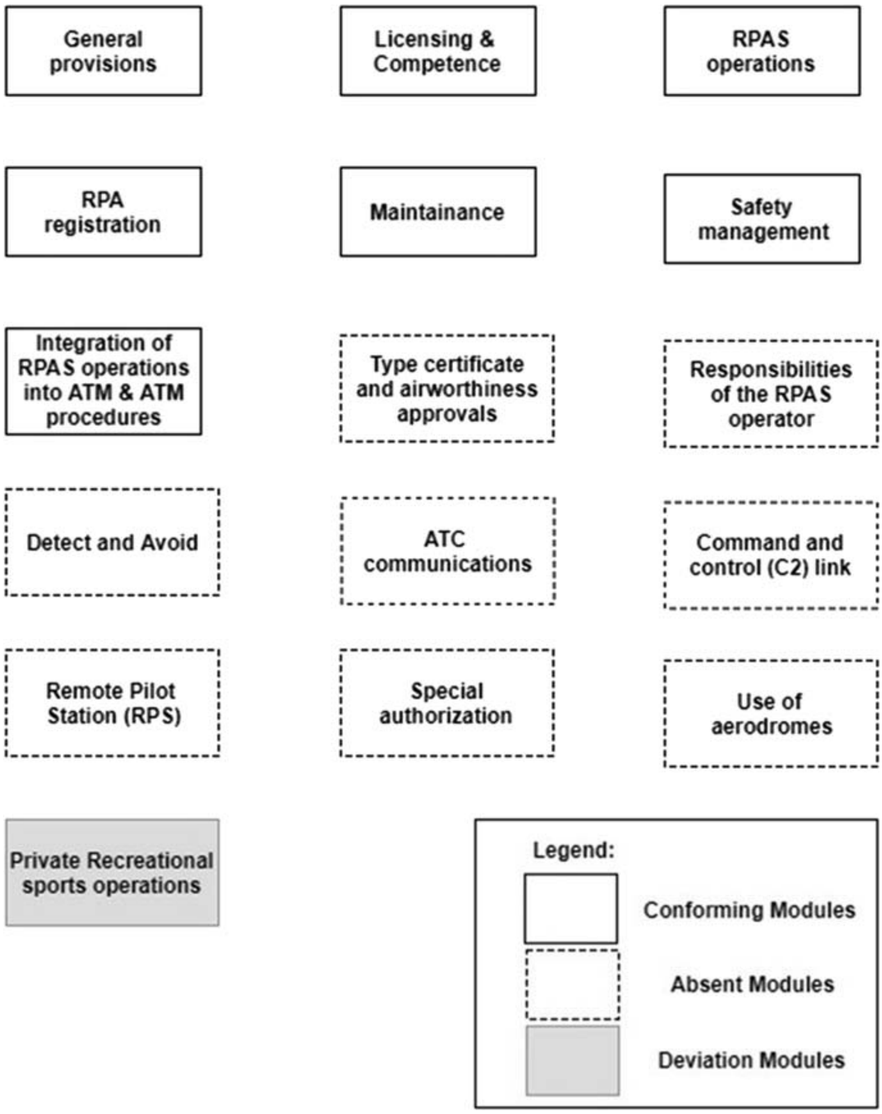

Figure 9. Decomposition view of Malawi's drone regulation.

especially the inclusion of its provision to meet the particular priority of the country. The drone regulation in Uganda will contain about 85% of (Table 1) provisions, which is a confirmation of the third stage in our proposed framework to adopt provisions already provided by ICAO. Again, there will be a defined provision (deviation provision) from the regulators, the (RPAS training and education standards, and frameworks provision).

The data extracted is in (Table 4) and subsequently, we decomposed the provisions of the new regulation. (Figure 10).

5. Conclusion

In this paper, we proposed a policy framework for developing drone regulations in Africa. The framework is evaluated in two case studies; (1) describing an existing drone regulation and (2) developing a new drone regulation. With both cases, the main results showed that the existing or new

Table 3. Conforming, absent, and deviation provisions with the reference model.

Country	Conforming provisions	Absent provisions	Deviation provisions
Botswana	GR, RPA-R, RESRO, RAO, PSC, RPAS-O,	SA, TCAA, LC, DAA, C2-link, AC, RPS, INT-RPAS, UA,	PNF, PPFO
South Africa	GR, RPAS-O, LC, RPA-R, MTN	SA, RESRO, DAA, AC, INT-RPAS, UA	–
Benin	SA, RPA-R, RESRO, SM, LC, RPAS-O, C2-link, UA	TCAA, DAA, AC, RPS, INT-RPAS	–
Rwanda	SA, TCAA, RPA-R, RESRO, SM, LC, RPAS-O, C2-link, AC, UA	INT-RPAS, RPS, DAA	–
Tanzania	SA, TCAA, RPA-R, LC, RPAS-O	RESRO, SM, DAA, C2-link, AC, RPS, INT-RPAS, UA	–
Zimbabwe	TCAA, RPA-R, RESRO, SM, LC, RPAS-O, C2-link, AC, UA, MTN	INT-RPAS, RPS, DAA, SA	–
Senegal	TCAA, RPA-R, LC	SA, RESRO, SM, RPAS-O, DAA, C2-link, AC, RPS, INT-RPAS, UA	–
Cameroon	SA, RPAS-O	TCAA, RPA-R, RESRO, SM, LC, DAA, C2-link, AC, RPS, INT-RPAS, UA	–
Gabon	RESRO, SM, RPAS-O, DAA, AC, UA	INT-RPAS, RPS, C2-link, LC, RPA-R, TCAA, SA	–
Madagascar	RESRO, SM, RPAS-O	SA, TCAA, RPA-R, LC, DAA, C2-link, AC, RPS, INT-RPAS, UA	SANC
Namibia	SA, RESRO, SM, LC, RPA-R, TCAA	RPAS-O, DAA, C2-link, AC, RPS, INT-RPAS, UA	PNF
Nigeria	SA, TCAA, RESRO	RPAS-O, DAA, C2-link, AC, RPS, INT-RPAS, UA, RPA-R, SM, LC	–

(SA) – Special Authorisation, (TCAA) – Type Certification and Airworthiness Approvals, (RPA-R) – RPA Registration, (RESRO) – Responsibilities of the RPAS operator, (SM) – Safety Management, (LC) – Licensing and Competencies, (RPAS-O) – RPAS operations, (DAA) – Detect and Avoid, (C2-link) – Command and Control (C2) link, (AC) – ATC Communication, (RPA) – Remote Pilot Station, (INT-RPAS) – Integration of RPAS operations into ATM and ATM procedures, (UA) – Use of Aerodromes, (GR) – General Requirement, (MTN) – Maintenance, (SANC) – Sanctions, (PNF) – Penalties and Fees, (PPFO) – Pre-flight Preparations and Flight Operations, (PRS-O) – Private Recreational Sports Operations, (RAO) – Restricted Areas of Operation, (PSC) – Precautions and Safety Consideration

Table 4. Extracting new drone policy or regulation provisions from a stakeholder in Uganda.

Adoption of provisions from ICAO / Defining own provisions		
Provision	Inclusion	Reason for inclusion
Special authorisation (SA)	√	Binding by Chicago Convention especially for RPAS operating across a different country as prescribed in ICAO manual
Type certificate and airworthiness approvals (TCAA)	√	Binding by Chicago Convention: ensuring multinational aspects in type design, manufacture, and operator requirements conform to agreed type certification as prescribed in ICAO manual
Remotely piloted aircraft registration (RPA-R)	√	Ensures responsibility
Responsibilities of the RPA operator (RESRO)	√	To ensure adherence to set safety management systems as prescribed in the ICAO manual
Safety management (SM)	√	To guide on limits and bounds of the safety management system as prescribed in the ICAO manual
Licensing and competencies (LC)	√	To ensure responsible professional handling and safety
Remotely piloted aircraft system operations (RPAS-O)	√	To ensure responsible professional handling and safety
Command and control (C2) link (C2 link)	√	Conformity to international standards as prescribed in the ICAO manual
ATC communications (AC)	√	As prescribed in the ICAO manual
Remote pilot station (RPS)	√	To better manage flights as guided by the ICAO manual
Use of aerodrome (UA)	√	Aerodrome information and frameworks are useful for safety especially at take-off and landing
Detect and Avoid (DAA)	X	Not sure whether this will be included but still deliberating on it
Integration of RPAS operations into ATM and ATM procedures (INT-RPAS)	X	Not sure whether this will be included but still deliberating on it
RPAS Training and education standards and frameworks	√	This is our provision we are including for country particular need

√ – provision adopted from Table 1, X – a provision not adopted from Table 1.

regulations contain about 40%–85% of conforming provisions to (Table 1) an indication that (Table 1) is a reference document for developing drone regulations. However, much research is needed to identify key challenges posed by regulations to the adoption of drones. Further studies are also needed to ascertain the current state of drone regulations in Africa and detailed characterisation of existing regulations.

Our study was not without limitations. The retrieval of drone regulation documents could have been extended to all African countries but this was limited to only those we could retrieve from the sources indicated in the methodology section. Some civil aviation websites were not updated to enable the retrieval of the regulation documents even though there might have been an established drone regulation in those countries. Also, although the drone regulations outlined various provisions, we were limited to the extent of information we could get in terms of parties and their capabilities involved in the development and enforcement processes, and political underpinnings. As a shortcoming of our study, it was impossible to compare countries' provisions with each other as the base for comparison was not even. For instance, Malawi regulatory provisions were retrieved from a presentation document (not the main regulatory document) and as a result, we resorted to mapping the retrieved regulations to the manual on RPAS from ICAO. Moreover, we have derived a general policy framework that can be made stronger when we retrieve even more data.

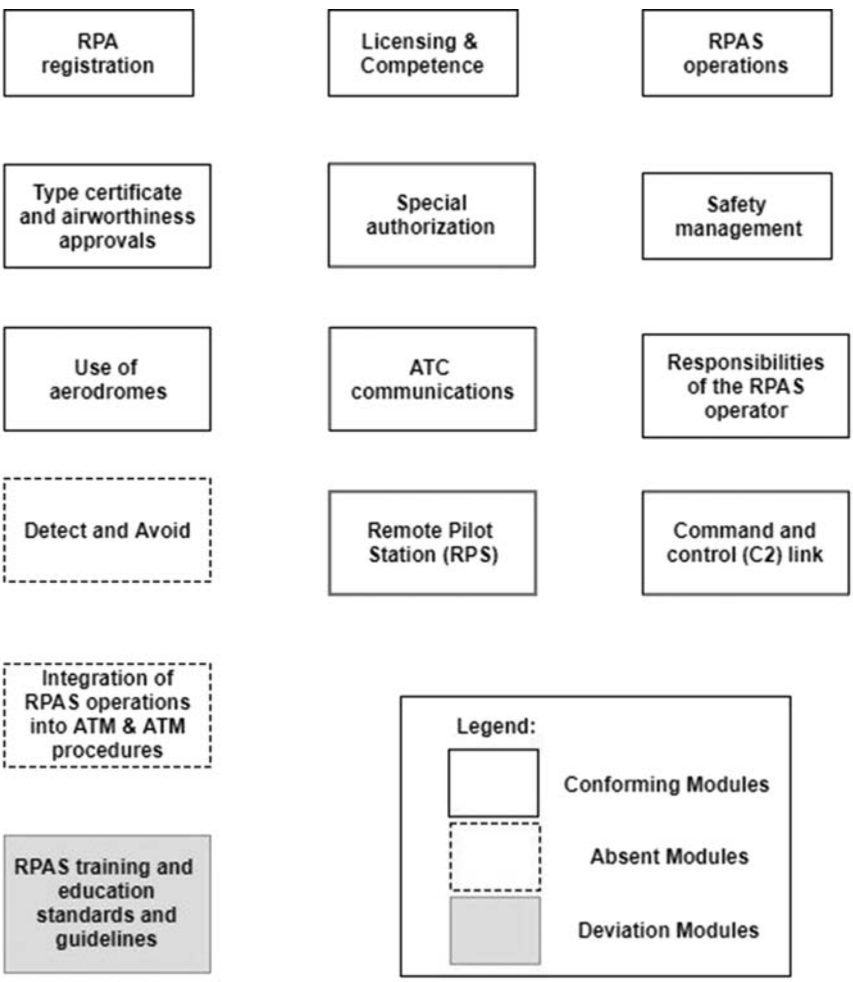

Figure 10. Decomposition view of the new drone regulation for Uganda.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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