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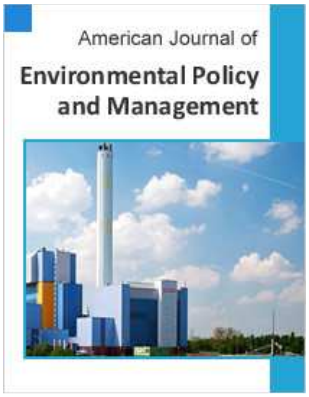

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Review of Potential Ecological Impacts of Peaceful Robotic Drone Use and Policy Implications for Developing Countries

Emmanuel Teryila Tyokumbur

Ecology and Environmental Biology Unit, Department of Zoology, University of Ibadan, Ibadan, Nigeria

Email address
e.tyokumbur@umail.ui.edu.ng

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Abstract
A review has been carried out on the potential ecological impacts of peaceful or civilian robotic drone use and its policy implications for developing countries. The author delves into the emergence of what has become today known as drones right from the late 16th century it was first used as a hot - air balloon through its evolvement over the decades inspired by the need for national defence and global peace. The article highlights the rapid departure from the tragic use of military - grade drones to peaceful or civilian uses in the last decade to policy implications for developing countries. The article gives succinct analyses of the reported and potential pros and cons associated with peaceful drone use in developed and developing countries with the aim of assisting the later in this unavoidable policy decision at hand. Suggestions are made on the way forward through approaches to arrive at policy criteria on peaceful robotic drone use in accordance with cultural, developmental, ethical and ecological needs, aspirations and peculiarities of developing countries in need of such a framework.

1. Introduction

The International Civil Aviation Organization defines a robotic drone as an aircraft without a pilot on board (ICAO, 2011). It is also known as a remotely piloted aircraft (RPA) or Unmanned Aircraft Systems or Vehicles (UAS or UAVs) whose flight is controlled either autonomously onboard by computers or by the remote control of a pilot on the ground or in another vehicle. Under the same ICAO Circular 328, classify unmanned aircraft into two types namely the autonomous aircraft which is currently considered to be unsuitable for regulation due to legal and liability issues while the remotely piloted aircraft is liege to civil regulation locally and internationally. Robotic drones have been used in highly advanced and sophisticated military and special operation operations for which they are conventionally known as harbingers of death or targeted killings. Interestingly, there has being a burgeoning number of civil applications that could impact the human environment in diverse ways (Franke, 2015). These uses include inspection and monitoring of power and pipeline installations (for gas, oil and water) and a host of other diverse surveillance suaveness in commercial aerial observatory work, filmmaking, journalism, search and rescue operations, demining, scientific research, civil defence, reconnaissance, national defence, conservation biology, oceanography and geological surveying (Tyler and Torin, 2011; Gremillet, *et al*, 2012; Fung, 2013; Kaufman and Somaiya, 2013, Ulrike, 2015).Drones or UAVs as they are

known elsewhere are often preferred for duties or missions that are by far too dangerous, obtrusive, dirty or dangerous for human access or for manned air systems.

Biologically, drone bees are male honey bees which are the product of an unfertilized egg which unlike the female worker bee do not have stingers to attack competitors, enemies and predators. They do not participate in nectar and pollen gathering even though they are the major beneficiaries of the hive's food resources and defence due to their primary role to mate with a fertile and receptive queen. Anatomically, drone bees are characterized by eyes that are twice the size of those of worker bees and queens possibly an adaptation to mark and sight out the queen for mating. Its body size is greater than that of worker bees due to greater access to the hive's food stores, even though it is usually smaller than the queen bee. The abdomen is stouter and more distended than the abdomen of workers or queen. Although heavy bodied, drones have evolved to fly sufficiently fast enough to accompany the queen during flight (Winston, 1991; Loper *et al*, 1992; Nickel, 2001; Oldroyd, 2006). Although there is little connection between the insect's biology and behaviour and the later use of this word "drone" that lead to its technological adoption or later use in lethal robotic manufacture and use in dangerous war theatres, it can best be ascribed to the tendency of both to fly and make a buzzing noise from wing or propeller flaps (Tyokumbur, 2015). As a result of the stigma associated with drones as vehicles or harbingers of death, most manufacturers have adopted the use of UAVs for purposes of gaining acceptability of their products intended for peaceful use of the technology. However, in this article, both terms are used.

From the point of view of developed economies, robotic drones for peaceful use are cheap, fun, and easy enough to use and control that they even make good gifts from tech - savvy families for festive seasons (McCormick, 2014) and were among the most popular Christmas gifts in Britain in the year 2014 (Ulrike, 2015).Thus given the immense benefits associated with civil use of robotic drones as listed above, there is the possibility that they may soon flood the markets and airspace of most developing countries on the continent of Africa and elsewhere hence the need to critically review its potential ecological impacts and policy implications. For the purpose of this review, the aim of this article is to focus on the potential ecological impacts of peaceful robotic drone use and its policy implications for developing countries.

2. Ecological Impacts of Robotic Drone Use

Drones have a long history dating back to the late 16th century when their precursors known as hot - air balloons were developed and later used by Austria to attack Venice in 1849 with a boomerang effect from the fully stocked explosives (Ulrike, 2015).Thereafter, it evolved during and after military warfare such as the two World Wars, Lebanon war, NATO operations and pacification, anti - terrorism and stabilization of failed states. In the past decade, drone technology has evolved into civil and peaceful use that can enhance the quality and welfare of life and bring in immense profits to the innovators. As a result of the increasing use, accessibility and affordability of peaceful robotic drones, there are consequently several impacts that it could have as a result of its widespread applications. This has been categorized by the author into beneficial and adverse impacts (Tyokumbur, 2015).

2.1. Beneficial Impacts and Uses of Robotic Drones in Ecology

From an ecological perspective, the beneficial impacts accruing from robotic drone use have been listed to include but not limited to the following:

i. Biodiversity conservation through the use of UAVs or drones equipped with cameras and sensors that include mini - computer, a Global Positioning System (GPS), a compass and an altimeter programmed using digital maps for monitoring wildlife in order to protect them from the activities of poachers. This has been widely used to monitor wildlife in East Africa, South Africa, United States of America, Switzerland, Greenland and Asia (Schlesinger, 2013).Drones could also be used to track wildfires that could have adverse impacts on wildlife and biodiversity.

ii. Aerial surveying and chemical spraying of crops. Specially designed drones can be fitted with fumigants in order to fumigate large flocks of sheep. herds of cattle as reared by herdsmen and in ranches, rangelands, open pens and poultry farms. (Ross, 2014, Tyokumbur, 2015)

iii. Environmental protection through the use of UAVs or drones to monitor power and pipeline installations. Power installations such as hydroelectric dams, generating and distributing centres have the potential of killing or displacing humans and wildlife due to impacts such as flooding, drowning, snake bites from floating snakes, enteric epidemics from drinking contaminated water and electric shocks whenever such facilities are vandalized in some developing countries, hence the need for aerial surveillance using drones or UAVs. Similarly, threatened oil and gas pipelines and related installations can be monitored using UAVs or drones not only to protect national economic interests but also to prevent oil spillage and fire explosions that have adverse impacts on the human environment (Barnard, 2007).

iv. Animal Rights Protection through monitoring to deter prized game hunting, illegal whaling (Franklin, 2012; Atherton, 2013) with a possible future use in the protection of Exclusive Economic Zones (EEZ) from illegal exploiters of national resources from the marine environment (Tyokumbur, 2015).

v. Aerial monitoring of air quality and pollution detection through equipping of drones or UAVs with meteorological and environmental monitoring sensors will enhance the quality of life especially in urban centres where exhausts from automobiles and industrial waste gases pose a threat to human health and the ecosystem (Tyokumbur, 2015).
vi. Search and rescue of reintroduced endangered wildlife that may have strayed from their territories after captive breeding. It could also be used to track, find and rescue lost skiers, hikers (Renaut, 2015) and hunters (Tyokumbur, 2015).
vii. Scientific research through propulsion of new science thereby opening up new fields of studies and discoveries that would otherwise have been unfeasible, unrealistic or unimaginable without the drone technology. These new ecological monitoring and research frontiers include bird and habitat protection, high - tech ecological impact assessments, animal migration, invasive species monitoring, EEZ monitoring, advancement of ecotourism through wildlife monitoring from spots of convenience, air and water quality monitoring, amongst others. All these will cumulatively enhance the quality of life and ecosystem services (Renaut, 2013, Tyokumbur, 2015).

2.2. Adverse Impacts from the Use of Robotic Drones

From the point of view of ecology, potential adverse impacts of robotic drone use include the following and are very critical to human health and survival as well as environmental sustainability. These include:

i. Bioterrorism through the use of drones to spray or spread harmful weaponized biological agents such as pathogenic bacteria, fungi, insects, toxins and viruses to cause or transmit disease. This assertion by the author is supported by claims that field testing had been done secretly and successfully with stimulants and actual agents that were disseminated over wide expanse of areas in some countries. Although the Biological Weapons Convention (BWC) of 1972 outlaws mass production, stockpiling and use of biological weapons, it inadvertently does not prohibit research into the defense or protection against biological weapons (BW).This means that the potential threat of using BW devices in drones used by civilians as a tool for bioterrorism cannot be ignored by regulatory agencies in developing countries and the BWC Office at the points of manufacture, shipment, import, export, distribution and use (Tyokumbur, 2015).
ii. Dispersal of acutely and chronically toxic or harmful substances. Impacts arising from the discrete ill - use of peaceful drones on local communities for antagonistic reasons may pose public health issues in the short and long - term especially in communities with communal differences and skirmishes. Such toxic substances that can be potentially spread through abuse of drone use include harmful radioactive isotopes, heavy metals, polycyclic aromatic hydrocarbons (PAHs), toxic ash from diverse sources such as incinerators, sanitary landfills, pesticides and even to contaminate municipal water reservoirs with hazardous substances whose health effects can only be noticed after several years of exposure depending on the quantity that is or intermittently dumped by the moderately sized robotic drones. This is not discouraging so long as the right regulation is in place in developing countries and the benefits as listed above remain overwhelming.
iii. Unverified sources include the potential of using peaceful drones for spreading substances intended for spirituality that may include tricking, stalking, conjuring, manipulating, harming or destabilizing perceived adversaries in some developing countries as observed on some movies that portray its reality. Although purely a religious impact, the fact that humans are involved makes it an aspect of the so - called spiritual ecology.
iv. Harmful effects on non - target organisms during crop spraying with pesticides could be an emerging threat to ecosystem health and sustainability (Tyokumbur, 2015). Although cheaper with greater potential for low - flying spray proximity impact on crops than a full - sized helicopter used for the same purpose, robotic drone pesticide could still be harmful to non - target organisms. In order to reduce this impact, botanicals and pest - specific chemicals have to be developed for the various distinctive ecological zones bearing in mind the flora and fauna of those agricultural areas.
v. Aviation safety. Although drones could be used at a distance from landing and take - off strips to monitor the presence of birds at airports to avoid bird strikes and siphoning into jet engines, they have been reported to pose a hazard to air travel having been sighted flying close to commercial planes in many countries (Mulrine, 2013; Elliot, 2014; Vincent, 2014). Quite a challenging technological device, robotic regulations in some developed countries provide for flying peaceful robots at not more than 400 feet the above ground and far away from airports as widely reported.
vi. Non - aircraft human safety accidents. Due to their vulnerability to power and communications failures, robotic drones have had much higher loss rate than conventional aircraft (Whitlock, 2015). Diverse accidents associated with peaceful drone use have been occurred and reported from its use in many countries. The accidents include crashes into infrastructural facilities, crashing into people and restricted areas and hampering air flight schedules (de

la Baume, 2014).

vii. It is expected that the hazard of noise from robotic drones would be set to meet the requirements for conventional aircraft categories in proportion to the technological airframes and propulsion systems used (ICAO, 2011).

viii. Peaceful drone use abuse through targeted killings and assassinations. It is a well documented fact that the political terrain in most developing countries is at its infancy with diverse teething problems such as unwillingness to accept defeats and inability to articulate people - oriented programs thereby culminating into religious and ethnic violence, assassinations, civil wars, terrorism, kidnappings, corruption and bigotry due to perceived superiority of the ideas of opponents. The author fears that except peaceful drones are well regulated and monitored, they may end up being fitted with guns and explosive devises to assail opponents or confine victims for a ransom in some developing countries. Although this has to do with a social dimension or domain to peaceful drone use, man as a biological animal cannot be ignored in the scheme of ecological studies (Tyokumbur, 2015).

3. Policy Implications of Peaceful Robotic Drone Use in Developing Countries

Given the almost balanced potential level of the benefits and harmful impacts associated with the use of robotic drones, it is imperative for developing countries to come up with a policy framework guiding its uses and applications. This is because peaceful drones are becoming increasingly cheaper, affordable and easy to use.

Although most countries where drones are being used as a hobby or other peaceful applications, regulations guiding their use have been evolving with advances in the technology taking into cognizance the ecological and environmental implications. It is timely for developing countries as members of the global community and economy to develop policy documents and standards that would govern their procurement and us at this auspicious time when the U.S Federal Aviation Administration through the authorization of Congress is warming up to open its airspace to unmanned aircraft in October 2015.

This proposed policy framework can come in the form of an enacting a legislation guiding its standards in manufacture, importation, exportation, assembling, use, recycling, disposal, height of flying, allowable flying distance (AFD) from airports, noise level, allowable substances and equipments on the toys, flying times at particular locations, minimum required age for acquisition and other licensing parameters like monitoring agencies or bodies for all peaceful drone use.

Research centres or institutes relevant to peaceful drone use are bound to emerge through development of policy document for the advancement, assembling and domestication of the technology.

In addition, prizes or chairs will have to be endowed to promote beneficial drone applications as currently in place in the United Arab Emirates' Drones for Good Annual Prize of $1 Million Dollars. For whether developing countries like it or not, peaceful drone use has come to stay with the potential of touching diverse aspects of our daily lives and so it's a matter of time before they will begin to be supplied into the markets.

4. Conclusion

From the foregoing review above, there is every need for developing countries especially those that do not have such standards and regulatory policies in place to quickly and urgently critically understudy the potential ecological impacts of peaceful robotic drone use and develop a policy framework best suited to its own needs. There is no doubt that this is an interdisciplinary team work at hand that requires professional expertise in ecology, engineering, technology, aviation, humanities, law makers and enforcers (customs, etc), policy makers, industry and other related areas. Interestingly, the market share for peaceful drones has been estimated to run into several trillions in diverse currencies which could expand the global economy and provide jobs and opportunities.

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