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Nuclear security and Somalia

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ABSTRACT

Scholars have not regarded Somalia as a place of relevance to thinking about nuclear security. This article gives four reasons why this perspective is not well founded. First, as the state strengthens it needs an International Atomic Energy Agency (IAEA) nuclear security regime for the control of nuclear materials. Second, it has unsecured uranium reserves that could be smuggled abroad. Third, those unsecured uranium reserves could be accessed by terrorists for use in a 'dirty' bomb. Fourth, there is evidence of past 'ecomafia' intent and planning, and possible success, in dumping radioactive waste on land in Somalia or in its territorial waters. The article proposes an innovative system of uranium ore fingerprinting, covert sensors, mobile phone reporting and surveying and evaluation capabilities that would address all four issues. The proposed system would include a low-cost method for turning any smart phone into a radiation detector to crowdsource reporting of possible nuclear materials, plus aerial and underwater drones with low cost radiation sensors.

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Introduction

Somalia is not a country usually associated with nuclear security issues. However, there are four reasons why Somalia needs a system of nuclear security. First, as the state rebuilds and increasingly functions domestically and internationally, it needs an International Atomic Energy Agency (IAEA) nuclear security regime, that is, an internationally coordinated overall approach to governing nuclear materials and associated activities. Somalia has made some preliminary steps towards this but still has a long way to go (IAEA, 2013). Second, Somalia has notable uranium reserves (see Figure 1), but no capability to deter, detect and prevent the illicit extraction and export of this radiological material. In the 1960s and 1970s Somalia granted a number of international licences to prospect for and mine its uranium ore but these plans did not come to fruition (IUREP, 1983, IV.2). Nevertheless, its main uranium deposits are surficial deposits which are easily accessible. Third, terrorists could put uranium ore in a dirty bomb which uses conventional explosives or other means to disperse radioactive material. Somalia's main uranium deposits are in Galmudug Federal Member State (FMS), where there is a significant al-Shabaab (AS) and growing Islamic State (IS) group presence. Fourth, Somalia has no capability to evaluate scientifically claims of nuclear waste dumping inland or off its coast, or to engage in containment or clean up. As we report below, extensive Italian Parliamentary investigations over many years

prove beyond doubt that Italy's 'ecomafia' intended and planned to exploit Somalia's state collapse in 1991 to dump radioactive waste on land in Somalia and in its territorial waters secretly and illegally. In other words, this is not merely rumour, speculation or conspiracy theory. In this article we debunk some false claims and show where others are overstated while still underlining the point that in some cases intent and planning to dump nuclear and other toxic waste in Somalia have been established conclusively. What remains unresolved is whether such dumping did in the end occur; the Italian Parliamentary investigations and those of other actors such as the United Nations (UN) have concluded that it is plausible that they did, with a number of specific possible sites identified (see Figure 1). This issue is a matter of intense and widespread interest among Somalis up to the present (e.g. Aidarus, 2019), and this includes when the anti-piracy EU Naval Force (EU NAVFOR) gives community outreach presentations. If any such claims made over the past thirty years are true, there is a risk of environmental and human hazards through accidental exposure, and the risk of terrorists acquiring such materials. Even if the planned dumping did not occur, Somalia needs to have a system to monitor its radiological materials. The continuing resonance of this issue is illustrated by the fact that a young Somali, Adam Matan, raised the matter with then US President Barack Obama in 2016 in a televised town hall exchange (Soohan Media, 2016).

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Figure 1. Somalia: Uranium deposits and main alleged nuclear waste dumping sites.

This article proposes a nuclear security system for Somalia that addresses the needs identified above regarding nuclear materials management and preventing nuclear smuggling, nuclear dumping and nuclear terrorism. It could be a key component of an IAEA-approved overall nuclear security regime that Somalia needs to have as part of the process of becoming an IAEA member. For all these reasons, this article is of potentially major significance for security and development within and beyond Somalia. Once developed, the infrastructure could, with some additional training and equipment, also be applied to non-nuclear toxic hazards. This article is the first scholarly output on nuclear security and Somalia. Except for occasional brief discussions of toxic waste dumping (e.g. Weldemichael, 2019, p. 26–30), no scholarly research has been published before on Somalia and IAEA membership or nuclear smuggling, terrorism or dumping.

The article outlines in two sections what a nuclear security system for Somalia might look like. The first section sets out in turn the main nuclear issues facing Somalia – its lack of an IAEA nuclear security regime; its

vulnerability to smuggling of uranium ore; potential terrorist access to uranium ore for use in a ‘dirty’ bomb; and the history of likely and proven illegal intent to use it as a site for nuclear waste dumping. The second section outlines the technical characteristics of a nuclear security system that would address these issues and provides a summary of the expected results from deploying such a system. The conclusion briefly integrates the elements of the argument into an overall case for the proposed nuclear security system.

Nuclear issues and somalia

Somalia’s uranium ore deposits have been public knowledge since at least the late 1960s. Although small in global terms, Somalia’s main uranium reserves are substantial, unsecured and close enough to the surface for strip mining (see Figure 1 and New York Times, 1968; Hussein, 2007; 2013). The main uranium deposits are in Galmudug FMS in central Somalia. Somalia has an estimated 10,200 tonnes of uranium reserves, with 7,600 tonnes of it potentially commercially recoverable,

though at relatively high expense (IUREP, 1983, IX.3; NEA and IAEA, 2018). The Alio Ghelle uranium ore deposit in South West State FMS is also unsecured but scattered, relatively far underground and of low grade (IUREP, 1983, IX.2.2, IX.3; The Diggings, No date). Uranium could be extracted from the unsecured Hamar betafite deposit in western Somaliland but it too is small scale and low quality with the additional challenge of being outside the normal areas of operation of AS and IS (IUREP, 1983, IX.2.1). For these reasons, the Alio Ghelle and Hamar deposits appear to be insignificant in relation to nuclear security. Nevertheless, a nuclear security system along the lines proposed here could evaluate this further using the IAEA's risk-informed framework and monitor their status. As the Galmudug deposits are large, near the surface and in a relatively insecure area, the uses of the system should prioritise them. We now discuss in turn the four nuclear security issues identified.

Lack of an IAEA nuclear security regime

Somalia does not have what the IAEA calls a nuclear security regime, the essential elements of which are: state responsibility for nuclear security; a nuclear legislative and regulatory framework; regulation of international transport of radioactive material; offences and penalties for violating nuclear regulations; commitment to international cooperation on nuclear issues; a capability to identify and assess nuclear security threats; a system for identifying and assessing targets of illicit nuclear activity and possible consequences of that activity; use of a risk informed approach in assessing nuclear threats; a capability to detect nuclear security events; an ability to respond to an adverse nuclear security event; and a commitment to sustaining the nuclear security regime. Somalia is not a member of the IAEA but has begun preparations for such an application (Herring, FGS, IAEA, 2016-19). It is an open question as to when it will apply, as there are many serious and competing demands upon the state, which has limited capacity. The IAEA and Somalia have each named Points of Contact for their interactions and Somalia was represented at the IAEA's first nuclear security school in Egypt in 2016. To assist Somalia in establishing its nuclear security regime, the IAEA Division of Nuclear Security worked with Somalia's Ministry of Petroleum and Mineral Resources to prepare a confidential Integrated Nuclear Security Support Plan (INSSP) in June 2016 that identified key activities to be carried out over 2016-2019. This plan was informed by Somalia's submission via the IAEA Nuclear Security Information Management System

online self-assessment questionnaire. It appears to be the case that progress has been minimal. The IAEA and Federal Government of Somalia (FGS) agreed to conduct an INSSP Review Mission in 2019 but to date that has not happened; if implemented, the nuclear security system we propose could be considered as part of that review.

Vulnerability to smuggling of unsecured uranium ore

At present Somalia is vulnerable to the possibility that some of its unsecured uranium ore will be smuggled abroad. In 2006 the UN Monitoring Group on Somalia claimed that Iran had supplied arms to the Islamic Courts Union (ICU) – the alliance of Islamic courts which dominated South Central Somalia that year. It also claimed that 'there were two Iranian personnel in Dhusamareeb [capital of Galmudug] engaged in matters linked to uranium in exchange for arms for [the] ICU' (UN SC, 2006, para., p. 89). Iran denied the claim about the arms and ignored the one about uranium ore. While the UN provided detail in relation to the arms it did not do so in relation to the uranium. Iran increased its engagement with Somalia from 2012 onwards as the new internationally-supported FGS began to consolidate. Due to the use of carrot and stick diplomacy by Saudi Arabia, Somalia severed diplomatic relations with Iran in 2016. In 2016 and 2017 Iranian weapons arrived covertly in the Puntland semi-autonomous FMS of north-east Somalia (UN MGSE, 2017, 29-31, 107-11), while in 2018 the UN reported the systematic smuggling of charcoal from Somalia to Iran (UN MGSE, 2018, 46-48, 142-152).

While there are, as we have just indicated, two-way smuggling channels between Somalia and Iran, claims of smuggling of uranium from Somalia to Iran seem to be false, even though there has been a more general pattern since the 1990s of verified attempts to steal, smuggle or sell African uranium ore or uranium yellowcake, with motives and parties involved unclear and disputed (Mutua, 2015). In August 2017 then Foreign Minister of Somalia Yusuf Garaad Omar wrote a letter to US Ambassador Stephen Schwartz in which he asserted the following: 'This issue can be summed up in a single word: uranium ... Al-Shabaab forces have captured critical surface exposed uranium deposits in the Galmudug region and are strip mining triuranium octoxide for transport to Iran' (Omar, 2017). Omar appealed to the US for immediate military assistance. Triuranium octoxide (U_3O_8 – also known as uranium oxide or yellowcake though it is usually brown or black) is produced through the mining, milling and chemical

processing of uranium ore in preparation for subsequent enrichment for fuel or weapons. We do not know the basis or origins of Omar's claim and he provided no evidence. His claims are unlikely to be true. Strip mining and industrial processes for producing uranium yellowcake would require heavy machinery and large-scale facilities that have never existed in Somalia, that AS and IS do not have and that would be easily visible to satellite monitoring and to Somalia's population and local authorities. One item reporting Omar's claim contained a photo captioned 'Uranium mines in Somalia' (Cochi, 2017). An online reverse image search shows that it is actually a photo of the Rössing uranium mine in Namibia. Furthermore, Iran produces yellowcake from its own uranium ore and imports uranium yellowcake from other countries such as Kazakhstan. This is all open and internationally permitted, and so covert importation of Somali uranium ore would be pointless and politically risky. The fact that the Trump Administration did not react to Omar's assertion, even though it is hostile to Iran and even though Omar's letter was reported on Fox News which President Trump follows closely, suggests that the claim was not taken seriously (Herridge & Gibson, 2017). Despite the fact that this particular claim is implausible, the discussions around these rumours show that the possibility of smuggling of Somalia's unsecured uranium ore is a concern.

Potential terrorist access to materials for radioactive dirty bombs

As the option of using a dirty bomb containing uranium ore to create fear and disruption more than physical harm is currently open to AS and IS in Somalia, action to remove that option is prudent. In its official propaganda IS has expressed explicit interest in acquiring a nuclear weapon (Saul, 2015), whereas there is no record of statements from AS about its attitude to nuclear materials. A dirty bomb spreads radiological material through an explosion or other means and is also known as a radiological dispersal device. A dirty bomb can cause physical harm to people by direct contamination, while the need for decontamination will inflict economic costs and cause wider disruption. Such a bomb can also generate fear and political consequences on a scale far larger than the direct physical threat would suggest. Uranium ore could be gathered in Somalia through low-tech small-scale excavation (WNA, 2018). Intact uranium ore is not a major radiological threat, being primarily an alpha (not gamma) radiation emitter. However, the particles that would be produced by a uranium ore dirty bomb would be

a serious threat to health if inhaled or ingested. Efforts to educate people about the limited direct physical threat in order to reduce fear make sense but are not a substitute for proper controls on radiological material. Although unsuccessful up to now, there have been efforts by terrorists and criminal networks to acquire such material (NTI, no date; Shuster, 2018; US NRC, 2018).

The part of Somalia that has the greatest uranium deposits is relatively insecure, and AS and IS must both be taken seriously as actors that might obtain access to Somali uranium. The Galmudug FMS authorities are only partly in control and are conducting an armed struggle with AS, aided by the Sufi Ahlu Suna Wal Jama (ASWJ) militia, the African Union Mission in Somalia, US air strikes, the FGS National Army and US-trained FGS special forces. In January 2018, in an event chaired by FGS President Mohamed Abdullahi Mohamed 'Farmaajo', the ASWJ and Galmudug FMS merged formally. Despite progress such as this, the merger process has not been smooth and may fall apart completely (HIPS, 2019). Furthermore, AS and IS continue to be robust and effective beyond Galmudug FMS. In October 2016 IS took control of Puntland port town Qandala before being expelled in December of that year (ICG, 2016). Since 2018, IS has continued to expand its operations in Puntland and south central Somalia (Weiss, 2019). IS has had some success in recruiting AS members, while AS has responded by killing those within AS it suspects of actual or potential disloyalty and hunting down IS members (Maruf & Joseph, 2018, ch., 16). AS pledged allegiance to al-Qaeda (AQ) in 2012. An indication of the escalating regional threat AS poses is that it is increasingly transcending its Somali origins in terms of East African operatives and pro-AQ ideology, as evidenced by its 15 January 2019 attack in Nairobi which killed 31 and injured 28 (Bryden & Bahra, 2019).

In contrast to south central and Puntland, the situation in Somaliland is more reassuring in relation to nuclear issues – the uranium deposits are insignificant economically and it has much better security from terrorism. Somaliland's unilateral secession from Somalia in 1991 is internationally unrecognised. Nevertheless, it is de facto self-governing and has a functioning state, albeit one with a low level of capacity. With the approval or at least acquiescence of the FGS, international actors engage with the Government of Somaliland through what is called the Special Arrangement. Somaliland's minor uranium ore reserves are located in its peaceful western region. Hence they are distant from Somaliland's eastern region which is claimed by Puntland and in which there are intermittent low-

intensity armed clashes that also involve clans and sub-clans. AS has not launched an attack in Somaliland since 2008. Any presence or support AS has in Somaliland is limited by the fact that the area is dominated by the Isaaq clan whereas AS, while it has had some success at both transcending and exploiting clans, mainly draws on the Rahanweyn clan and has recruited few Isaaq (Hiraal Institute, 2018). The Somaliland population are united in their rejection of AS; the people, in part through a system of urban neighbourhood watch, are vigilant and report to the authorities any suspicious people or activities. These points should not be overstated, as can be seen from the fact that the AS leader Ahmed Abdi Godane, killed in a US airstrike in 2014, was an Isaaq from Somaliland's capital Hargeisa (Maruf & Joseph, 2018, p. 234–246). There may be an AS presence in Somaliland and it could become much more active if AS decided there was strategic advantage in making it so.

Vulnerability to nuclear dumping

In the 1980s and especially in the wake of the collapse of the state of Somalia in 1990, criminal gangs sought to dump nuclear waste and other toxic materials illegally on land in Somalia and off its coast. These facts initially surfaced as allegations in local Somali media and were repeated by Mostafa Tolba, head of the UN Environment Programme (UNEP) in December 1991 and in a UNEP statement in September 1992; this in turn generated international news media coverage (e.g. MacKenzie, 1992). Evidence in the form of documents, wire taps and testimonials by some of those involved proves that various combinations of the Calabrian mafia in Italy called the 'Ndrangheta, other professional criminals, corrupt politicians and officials, and Italian and Swiss companies intended and planned to engage in toxic – including nuclear – waste dumping in Somalia and in its waters, in some cases with the agreement of Somalis in their pay. The salience of an Italian interest in Somalia is partly explained by its previous role as the colonial power in Puntland and south central Somalia (whereas Britain was the colonial power in Somaliland). The main driver was to make money by disposing of toxic waste at a much lower cost than would be possible in Europe by legal means and hence to take advantage of Somalia's civil war, state weakness and state collapse. While toxic waste dumping elsewhere by the ecomafia has been proven, we do not have public, verifiable proof in the form of scientifically identified toxic materials that the plans were carried out i.e. that nuclear dumping actually occurred in Somalia or off its coast. Instead, we have numerous, often quite specific, claims, some of

which could be used as the basis of worthwhile field-work even now after the passage of a considerable amount of time. Some observers have deduced the possible presence of toxic materials due to reports of incidences and patterns of illness and death in the local population but no scientifically valid diagnostic or epidemiological research has been carried out. Existing documents that could be analysed for further leads and there is potential for interviews as many of those involved are still alive. Even if it turns out that no nuclear or other toxic waste was dumped in Somalia or off its shores, the fact that there was the demonstrated intent and planning to do so to take advantage of Somalia's lack of ability to control its land and seas shows that the lack of a capability for monitoring is an incentive to exploit state weakness. We now set out the most important findings and allegations in relation to nuclear dumping. We have organised them around groupings of perspectives – Italian and other European, UN and then Somali.

Italian and other European perspectives

The illegal disposal of hazardous waste on a massive scale by an 'ecomafia' of Italian companies and criminal gangs is a long-established fact; the term 'ecomafia' was coined by Italian Non-Governmental Organisation (NGO) Legambiente in 1994 (Massari & Monzini, 2004, p. 289). Iliari Alpi, an Italian journalist, and her Italian camera operator, Miran Hrovatin, were murdered in Mogadishu on 20 March 1994. Somali citizen Hashi Omar Hassan was convicted in Italy of the double murder. 'Ndrangheta member Francesci Fonti claimed in 2009 that Alpi and Hrovatin were killed because they had witnessed the arrival of toxic waste in the Puntland port of Bosaso (Hooper, 2006). Hassan served sixteen years of a twenty seven year sentence before being paroled in 2015. His conviction was overturned in 2016 by an Italian court and in 2018 the Italian authorities considered reopening the case based on wiretap evidence gathered in 2012 (ANSA, 2018). The Alpi-Hrovatin case and its connections to the ecomafia is an ongoing *cause célèbre* in Italy, as can be seen from the publication of various non-academic books (principally, Carazzolo, Chiara, & Scalettari, 2002; Cavalli, 2014; Carni, 2018; Grimaldi & Scalettari, 2019; Lucarelli, 2018) including one by Alpi's mother (Alpi, 2017), plus documentaries on Italian television (Minoli, 2013; Moreira, 2010).

The Italian authorities investigated the issue of the ecomafia and its use of 'toxic ships' and 'disposable ships' (to be filled with toxic waste, taken out to sea and sunk) extensively between 1994 and 2018. In the

process they gathered a vast amount of evidence and produced numerous reports. A list of official documents released in 2014 runs into the thousands of items in Italian (Greenpeace Italy, 2014) – and all of this is in addition to the many official Italian reports that have always been in the public domain. The Commission of Inquiry set up an online archive of public and declassified documents and audiovisual materials. The documents section lists over 2,000 items from 1973 to 2006, including 225 declassified ones (ASPI, no date). The Italian authorities' investigations were sprawling in their coverage, and systematic analysis of the materials with a focus on Somalia – including dumping at sea – has not yet been conducted. The fact that some testimony has been disproven underlines the need for direct checking of claims through fieldwork. For example, in 2006, Francesco Fonti, a former 'Ndragheta boss turned informer, said that he was directly involved in sending toxic waste to Somalia and sinking ships off the Italian coast loaded with toxic waste. In 2009, prosecutors located one ship off south-western Italy where Fonti said one would be, but it turned out to be a wreck from the First World War (Willan, 2001; Hooper, 2006; CPI, 2013, p. 105–106).

The existence of schemes to dump toxic, including nuclear, waste in Somalia has been proven. Even those that were exposed – and terminated as a result of that exposure before they were implemented – are still important because they are evidence of intent. Furthermore, some of these schemes reached an advanced stage of preparation.

Uranus 2 was one such project proving intent. Franco Oliva, an Italian aid worker in Somalia from 1986 to 1990, told the Commission of Inquiry that Guido Garelli, an Italian businessman based in Mogadishu, who he met there before 1990, was surprisingly open with him. Garelli told him that he was working with Giancarlo Marocchino (an Italian fixer based in Mogadishu and a central figure in ecomafia operations regarding Somalia) and some Somali officials to dispose of nuclear waste in the country. Uranus 1 was the code name of the ecomafia's project to dump toxic waste in the Sahara; Garelli was working to extend it to Somalia as Uranus 2 (CPI, 1995, 32. See also Carazzolo, Chiara, & Scalettari, 1998; Kingston, 2007; Greenpeace Italy, 2010; EJS, 2011). An entrepreneur in the Lombard region of Italy informed the Italian authorities that he had been contacted by Professor Ezio Scaglione of Alessandria to see if he would be interested in working with him to export toxic, including radioactive, waste to Somalia as part of Uranus 2. The Italian authorities established surveillance and discovered that Marocchino was closely

involved with the plan and appeared to be experienced in such operations. Marocchino proposed the rapid shipment of two or three thousand barrels of toxic waste, claimed that he had the cooperation of local clan leader, Ali Mahdi Mohammed, and indicated that 'El Bahraf (Ceel Baraf near Mahaday Weyne north of Mogadishu) had been selected for the most dangerous materials. Marocchini and Scaglione also said that they would misrepresent the site as an incinerator for urban waste in order to overcome concerns of clan leaders (CPI, 2003, 4–6. See also, 2018, 84–91; Huband, 1992). Mohammed received some international backing for his claim to be President of Somalia between 1991 and 1997 but exerted little control outside of Mogadishu. An official document signed by Mohammed and dated 19 August 1996 authorised Scaglione to establish and run a plant for processing waste in Somalia before the plot was exposed and shut down (Office of the President, Somali Republic, 1996. See also Greenpeace Italy, 2010, p. 22).

Another significant plan proving intent to use Somalia to dump nuclear waste involved Italian citizen Giorgio Comerio. At the end of the 1980s he represented a company called Ocean Disposal Management (ODM) which proposed using free fall penetrators to drive radioactive waste from wealthy countries into the seabed in the vicinity of mainly poor countries (ODM (Ocean Disposal Management Inc), 1983). The company approached many countries, including Somalia in July 1989 (State Prosecutor, Reggio Calabria, 1995). ODM came close to securing deals with the Ukraine, Russia and North Korea for such work but the exposure of these activities brought them to an end in 1996 (CPI, 2018, 90; Greenpeace Italy, 2010, p. 20).

The two cases in which the evidence is strongest that toxic, possibly including radioactive, waste was actually disposed of on land in Somalia are those relating to the Bosaso-Garowe road in Puntland and to the construction of the small Ceel Macaan port near Mogadishu. We also assess the evidence of possible nuclear dumping at Xaafun as sufficient to make it a priority for investigation. We have marked all three on our map (see Figure 1). This should not be interpreted as meaning that no other claims are worth investigating, only that these three are our top initial priorities based on current understanding. Reporting through the proposed system could change those priorities. Furthermore, as many locations along the coast of south central Somalia and Puntland have been identified as possible locations of washed up suspect objects, the operators could engage in systematic surveys using the aerial drone system we suggest to investigate these locations.

Regarding the first main case, the dumping seems to have occurred between December 1987 and January 1988 during the construction of the road between Garowe and Bosaso in Puntland. The Commission of Inquiry found evidence of this toxic waste dumping to be reliable because it was detailed, came from multiple sources, included direct admissions gathered from wire taps, was not contradicted by others involved in the work and because journalist Luciano Scalettari had Global Positioning System (GPS) coordinates and detected metallic material underground using a magnetometer in the locations indicated to them by some of those involved, including two truck drivers. However, they did not dig up the metal objects and their contents for testing. The truck drivers said they were told the containers, which weighed around 20 kilogrammes each, contained 'expired paint'. One site was 90 kilometres and the other 140 kilometres down the road from Bosaso to Garowe. The wiretaps about this scheme include references to the waste as including 'uranium' and 'yellow cake' (CPI, 2006, 96–102; EJS (Environmental Justice for Somalia), 2011, 7'43"-8'24"; Greenpeace Italy, 2010, 24–25; Hussein, 2010a).

Regarding the second case, Scaglione told the Italian authorities that, during the construction of the Ceel Macaan port in 1996 to 1998, Marocchino told him that he was able to dispose of radioactive waste in containers that would form part of the foundations of the quay. Giancarlo Ricchi who was working in the port took five photographs, supposedly of the containers, and said that Somali workers estimated that about four hundred containers had been buried. The photos are now public but they are unclear and exact knowledge of the contents of the containers has never been established (CPI, 2004, p. 25–26).

The Alpi-Hrovatin case and the work of the Italian authorities inspired a team of Italian and Swiss journalists to travel to numerous locations in Somalia in 1998 as part of a six-month investigation into toxic waste dumping in Somalia. They published their findings in the Italian newspaper *Famiglia Cristiana* (Carazzolo et al., 1998) and also gave evidence to the Italian Parliament. They made four new major claims. First, General Mohammed Said Hersi 'Morgan', the Minister of Defence from 1990–1991 for dictator Siad Barre and then warlord who controlled Kismayo in Jubbaland from the end of 1993 until 1999, told them that unnamed foreign companies approached him for land on which to store radioactive and other toxic but he refused. Second, according to Morgan nuclear waste was burned in the vicinity of Warsheikh, on the coast north of Mogadishu, in 1992. Third, according to Aldo Anghessa, an Italian arms dealer who had cooperated

with the Italian secret service, one dumping project, for nuclear waste, was named 'Salt Island' after the salt pans in the Xaafun peninsula in Puntland. The site was on the uninhabited north west of the peninsula, accessible only by sea. Also according to Anghessa, this was one of five such sites on the central and northern coast of Somalia. Garelli told the Italian authorities that US radioactive waste was dumped in a remote area of the Xaafun peninsula, guarded by people with Stinger missiles (CPI, 2004, p. 24). Fourth, an unspecified source told them that a warehouse of toxic materials encased in concrete and guarded by non-Somalis five miles inland and six miles north of the coastal town of Hobyo in Galmudug was established, with dumps in some other locations underground. Fifth, they gathered additional detail to that already known relating to claims that unusual patterns of illness and death among people and animals occurred in Somalia between 1995 and 1998 (see also Weyler, 2006; Hassan, 2009, 13–14, 37–40). The evidence and allegations compiled by the journalists and set out in the further exploration by the Italian authorities are sufficiently concrete to enable evaluation of some of them on the ground.

UN perspectives

For its part, the UN verified as far back as the early 1990s that efforts were made by the ecomafia to launch projects to dispose of toxic waste in Somalia and off its coast and investigated further on occasion. In December 1991, Tolba stated that Italian and Swiss waste-trading companies – which he did not name – had agreed a twenty year contract with Nur Elmy Osman, the self-proclaimed Minister of Health in a Somali civil war faction, to establish and run in the vicinity of Mogadishu a plant to store or incinerate up to half a million tons of hospital and industrial waste annually and would pay their Somali counterparts US\$80 million in return. In September 1992 *New Scientist* reported that it had obtained a copy of the contract, which showed that Swiss company Achair & Partners was the one involved (MacKenzie, 1992). There is no evidence that the plant was built or the waste actually shipped, and the contract was rescinded when it was exposed, with Achair & Partners and another Italian company Progresso Srl run by Marcello Giannoni both turning out to be front companies created to facilitate the deal (Greenpeace Italy, 2010, p. 22). Tolba also indicated that a Swiss company was planning to use two incinerator ships that would operate near the coast of Somalia. What happened with them has not been established, although incinerator ships, designed to dispose of toxic wastes as a cheaper and less legally challenging alternative to trying to secure permission for disposal or incineration on land,

did exist in the 1980s (Stammer, 1985). In 1992 the UN sent two missions to Somaliland, gathered some field samples and conducted some stakeholder interviews but found no evidence of toxic waste (UN SC, 2011). UNEP commissioned Mahdi Gedi Qayad, a Professor of Chemistry at the University of Mogadishu, to investigate the waste dumping claims from 10 May to 8 June 1997 (Qayad, 1997). According to the Italian and Swiss team of journalists, Qayad's report included photos and video of an object on the beach between Cige and Mareed near Adale north of Mogadishu that fishermen said had made them ill; the death of a fisherman after contact with an object on the beach at Baraawe (also known as Brava); and claims of hazardous waste in the vicinity of a number of places including Jamaame near Kismayo and in the Shebelle River swamps at Lambar 50 between Merka and Mogadishu. The report has not been made public and the journalists indicated that they had obtained a copy but have not made it public either (Carazzolo et al., 1998).

The UN took a renewed interest in these issues after the tsunami of December 2004, which resulted in objects washing up on the coast of Puntland and south central Somalia that some worried contained nuclear or other toxic waste. There was sufficient concern to trigger a UNEP investigation. The UNEP rapid desk assessment carried out in February 2005 was part of its response to all countries impacted by the tsunami. The report made the following claims:

Starting from the early 1980s and continuing into the civil war, the hazardous waste dumped along Somalia's coast comprised uranium radioactive waste, lead, cadmium, mercury, industrial, hospital, chemical, leather treatment and other toxic waste. Most of the waste was simply dumped on the beaches in containers and disposable leaking barrels which ranged from small to big tanks without regard to the health of the local population and any environmentally devastating impacts (UNEP, 2005, p. 134).

The report framed such dumping as a 'violation of international treaties' regarding hazardous waste exports and criticised any agreements with a divided government unable to enforce environmental standards or legal safeguards. It summarised the situation as follows:

The impact of the tsunami stirred up hazardous waste deposits on the beaches around North Hobyo (South Mudug) and Warsheik (North of Benadir). Contamination from the waste deposits has thus caused health and environmental problems to the surrounding local fishing communities including contamination of groundwater. Many people in these towns have complained of unusual health problems as a result of the tsunami winds blowing towards inland villages. The health problems include acute respiratory infections,

dry heavy coughing and mouth bleeding, abdominal haemorrhages, unusual skin chemical reactions, and sudden death after inhaling toxic materials (UNEP, 2005, p. 134).

The report concluded that 'dumping of toxic and harmful waste is rampant in the sea, on the shores and in the hinterland' (UNEP, 2005, p. 129). It asserted that a key motive for the dumping was the relative cheapness of doing so in Africa in comparison with Europe. It included a map of unspecified origin indicating eleven toxic waste sites along the coast and a further four inland in south central Somalia and Puntland; a photograph provided by the Transitional Federal Government of Somalia of a suspect drum on the shore on an unspecified location; and a photo of an unspecified hole in the ground provided by a resident of Hobyo (UNEP, 2005, p. 135). Other than this, the report provided no supporting evidence and so appears to be a summary of allegations. In March 2005, UNEP spokesman Nick Nuttall said the following:

Initial reports indicate that the tsunami waves broke open containers full of toxic waste and scattered the contents. We are talking about everything from medical waste to chemical waste products ... We know this material is on the land and is now being blown around and possibly carried to villages. What we do not know is the full extent of the problem ... We need more information. We need to find out what has been going on there, but there is real cause for concern ... We now need to urgently send in a multi-agency expert mission, led by UNEP, for a full investigation.

Nuttall also said that a UN assessment mission to Somalia found some Somalis in the north to have illnesses consistent with radiation sickness (Clayton, 2005). However, no such mission seems to have been sent although one was planned initially but postponed for security reasons. In May 2005 the UN took water samples at the Puntland coastal towns of Xaafun, Bandarbayla and Eyl but found no evidence of toxic waste (UN CTS, 2005). The scientific report has not been made public, although Somali researcher Zeinab Hassan reports having seen a copy (Hassan, 2009, p. 12).

Since its flurry of UN activity in 2004–05, the UN has continued to draw attention periodically to the issue. In 2008 UNEP spokesman Nick Nuttall was unequivocal and dramatic:

Somalia has been used as a dumping ground for hazardous waste starting in the early 1990s, and continuing through the civil war there ... The waste is many different kinds. There is uranium radioactive waste. There is lead, and heavy metals like cadmium and mercury. There is also industrial waste, and there are hospital wastes, chemical wastes – you name it ... What is most alarming here is that nuclear waste is being dumped.

Radioactive uranium waste that is potentially killing Somalis and completely destroying the ocean (Quoted in Abdullahi, 2008).

Special Representative for the UN Secretary General in Somalia Ahmedou Ould-Abdallah concurred with these views: ‘There is no government control . . . and there are few people with high moral ground . . . yes, people in high positions are being paid off, but because of the fragility of the Transitional Federal Government, some of these companies now no longer ask the authorities – they simply dump their waste and leave’ (Quoted in Abdullahi, 2008. See also AFP, 2008). Ould-Abdallah said that he had ‘reliable information’, which he did not reveal, that Asian as well as European companies were dumping toxic, including nuclear, waste off Somalia’s coast. The most recent major UN statement was made on 25 October 2011, when then Secretary-General Ban Ki-moon summarised the position for the Security Council as follows:

Allegations of the illegal dumping of various types of waste, including radioactive, hazardous and medical, on land and in Somali waters, have been made for almost 20 years. Circumstantial evidence indicates that the dumping of illegal waste occurred during the 1990s, but verification has not been possible due to the security situation in Somalia. Further investigations are needed to ascertain the validity of both historic and more recent claims. Information about illegal hazardous waste dumping off the coast of Somalia is unconfirmed, but stems from reputable sources and related data (UN SC, 2011, p. 12-13).

In essence, then, the UN line is that there is credible evidence of toxic waste dumping but that systematic fieldwork is required to evaluate the claims properly.

Somali perspectives

Foreign toxic waste dumping has for many years been a matter of intense interest among Somalis but this has not translated into any in-depth and verifiable Somali research, mainly due to the lack of resources and training for such research among them. Two brief syntheses and commentaries by Somalis – Abdullahi Elmi Mohamed and Mohamed Abshir Waldo – have become quite well known among those focused on Somali affairs (Mohamed, 2001; Waldo, 2008). One slightly longer one by Bashir Mohamed Hussein is also in circulation; this is based mainly on some of the sources already discussed above, with some additional references to items in the Italian news media, especially in relation to patterns of illness in Somalia perceived by some medical practitioners to be unusual (Hussein, 2010a, p. 10–13). This report contains a photo attributed to the Somali news

website dayniile.com of a man in the Lower Shabelle region of Somalia with a severe unspecified skin condition. There is no indication of who took the photograph or whether the skin condition or its cause has been identified. In another short paper, Somali Abdulkadir Egal argues tentatively that the cancer rate in Somalia has increased since 1993 and that this increase may be due to the presence of toxic waste (Egal, 2009). He obtained information from the Red Crescent Hospital in Dubai about the place of residence, age and gender of thirteen Somali cancer patients in 2003–04 and combined that with familiar general information about dumping. The paper, as the author accepts, is speculative and inconclusive.

The most important investigation involving fieldwork by anyone into the dumping claims was carried out in April–May 2006 by Mogadishu-based Somali Non-Governmental Organisation (NGO) *Daryeel Bulsho Guud* (DBG – Community Care for All). A German aid organisation (possibly Diakonie Emergency Aid or Bread for the World, Germany – DBG was affiliated to both) funded equipment, protective gear and training from a consultant to carry out the research. DBG claimed to have confirmed that fifteen containers it examined on the coast of Somalia contained ‘nuclear and toxic wastes’. According to Zeinab Hassan, the areas they indicated were around half of the coastal districts from Hobyso southwards: ‘Iidan coast (Hobyso district); Hin Dawa’o, Fah, and Qosoltire coasts (Harardhere district); Waahweyn and Mareg coasts (Eldher district); Jamal coast (Adale district); Havai coast (Mogadishu coastline); Hijo-mahad coast (Barave district); El-Bakari, El-Shid, Esole, El-lahelay, and El-Ganane coasts (Jamama district); and Koyamo coast (Kismayu district)’ (Hassan, 2009, 10. For some of the photos see also Milton, 2009; Hussein, 2010b). Hassan’s short paper is the most thorough and critically engaged piece by a Somali on the dumping issue. It supplements the usual sources with interviews, including with DBG staff, conducted in person in south central Somalia and Nairobi and on the phone. Her paper includes thirteen photos by DDG of containers, more than any other source referring to the DBG report. They are photos of metal cylinders on beaches about three metres long and two metres in diameter, in many cases being inspected by two people wearing gas masks and orange protective clothing. While DBG showed Hassan their report, they declined to give her a copy. DBG has not published its report subsequently and has not responded to a request from us for a copy, and so it is not possible to evaluate its validity.

A widespread, though not universal, view among Somalis is that Somali piracy is a defensive response to

illegal, unreported and unregulated (IUU) foreign fishing and toxic waste dumping (e.g. Abdullahi, 2008). This narrative is one that Somali pirates themselves espouse; it has the advantages of positively framing their identity and legitimating their behaviour to themselves and others, both locally and internationally (Bueger, 2013). Stig Jarle Hansen (2011) has argued that Somali piracy is essentially about the pursuit of profit rather than the defence of fishing and the environment, with the defensive motivation as mere rationalisation that should be undermined. However, this does not account for why Somali piracy increased from around 2001 and escalated from 2005 until it was suppressed from 2012 onwards. IUU fishing in Somali waters was rampant in the lead up to and during this period, including close to the shore, as foreign fishing vessels exploited the weakness of the state. Both sides in this conflict between foreign fishing vessels and local fishermen armed themselves and it escalated. Over time to a great extent, but not exclusively, it became the pursuit of profit from ransom by criminal pirate gangs, with the defensive motivation as rationalisation. In other words, as Awet Tewelde Weldemichael (2019) argues, the impact of foreign fishing fleets and indignation due to the belief that toxic waste was being dumped contributed materially to the rise in piracy; criminal pursuit of profit is not the whole story.

A system to address Somalia's nuclear issues

The nuclear security system proposed below if implemented would address all four of the nuclear security issues identified in this article – lack of an IAEA nuclear security regime, vulnerability to smuggling of uranium ore, potential terrorist access to materials for radioactive dirty bombs and vulnerability to nuclear dumping. It could do so by fingerprinting Somalia's uranium ore deposits so that they are traceable to their origins should they be smuggled abroad illegally; deploying a system of covert sensors to detect and report illegal movement of uranium ore; crowdsourced reporting via a mobile phone app of suspected radiological material (whether from possible historic dumping or contemporary uranium ore smuggling); and capabilities for assessing the presence of radiological materials through aerial, underwater and ground surveys. Securing and cleaning up of any nuclear materials located, identification of waste dumping culprits and their possible prosecution or action against would-be uranium ore smugglers or dirty bomb terrorists would be a matter for the relevant national and international authorities. The system needs to be designed and deployed in a way that protects society, property and the environment from the harms

associated with the nuclear security vulnerabilities identified while not unintentionally creating other harms such as panic or incentives for hostile entities to disrupt or exploit these systems. The system would have to comply with the relevant UN, IAEA, EU and national (especially UK and US) legal and regulatory requirements, most obviously as they relate to export controls, arms embargoes, dual use technology transfers (that is, transfer of civilian technologies such as drones with potential military applications), knowledge transfers, bribery and corruption, data security and the movement, storage and disposal of uranium ore samples. It could be supplemented in a variety of ways, principally through the use of satellites or epidemiological research. We now consider in turn the key tasks of the proposed nuclear security system, i.e. fingerprinting uranium ore deposits, deployment of covert sensors, rolling out of a mobile phone app and creating of capabilities to survey for (and respond to sensor and mobile phone app reports of the movement or presence of) radiological material. We conclude this section by outlining the expected results of the deployment of such a system.

Fingerprinting Somalia's uranium ore deposits

The main purpose of the uranium fingerprinting strand would be to produce a forensic database of the unique characteristics ('fingerprints') of the uranium in Somalia. If uranium ore then turns up somewhere in transit through Somalia or outside Somalia, it could be tested and compared to the fingerprint database. The system operators would collect uranium deposit samples. The sample locations and sample frequency would be determined from initial aerial drone surveys, backpack radiation mapping systems and measurement results. The equipment required for such work is not complex or costly; the team would need Personal Protective Equipment suits, sampling kits, Geiger counters, backpack radiation mapping systems, petrological microscopes, aerial drones with radiation mapping payloads, a laptop to collect and process data in real-time, a polisher and set of polishing equipment, a thin section prep instrument and an X-ray Fluorescence machine. The samples could then be shipped abroad to a partner country for more in depth analysis requiring more advanced equipment not available in Somalia. The mineralogy and major element analysis would have to be carried out using Scanning Electron Microscopy/Energy Dispersive Microscopy. Trace and rare earth element impurities could be measured using Electron Probe Micro-Analysis and isotope analysis could be performed using an Inductively Coupled Plasma Mass Spectrometer.

Deployment of sensors to detect movement of uranium ore

One way to detect unauthorised movement of material from uranium deposits is to measure fluctuations in radiation at tactical locations like roads, checkpoints, bridges, ports and so on. Somalia's nuclear security system should have camouflaged, autonomous, tamper-proof radiation sensors that are appropriately robust, inexpensive and low maintenance while still carrying out what is required of them. The sensor system should be deployed in the vicinity of the uranium deposits in Galmudug, between the deposits and the seaports of Mogadishu and Bosaso, and at additional locations identified through risk assessment. The system could be based on sensors originally developed for seismic applications; such sensors measure parameters such as ground acceleration along three axes, temperature and pressure on a regular basis. When a seismic event occurs, the sampling rate goes up. The sensors should be equipped with Geiger-Müller or Chemical Vapour Deposition diamond modules to detect radioactivity and should be equipped with a small camera. The sensors should be battery powered and upload their data over the Global System for Mobile communication network every hour to the same database that could be used for the mobile phone app discussed below. If a signal was detected by several sensors along the same road in sequence, the system operators would know the direction of travel. The sensors could be disguised as rocks or other inconspicuous objects. The sensors could be tamper-proof by enabling them to monitor environmental variables; any anomaly in temperature, humidity and light level or a small mechanical shock or recording incongruous photos or not receiving data at all, could trigger an alarm in the central database. The anomaly could be investigated on the ground to see if there has been a technical fault or tampering and ascertain the nature of that fault or tampering.

Rollout of a mobile phone app to report the possible presence of radiological material

The Federal Government of Somalia could make a mobile phone radiation dosimetry app available openly as a free download. This would allow anyone, such as a member of the public, a member of the security forces or someone on a fishing boat, to report an object they suspect of containing radioactive material. The app could be designed to take a short movie, which would give visual information on the object and, more importantly, analysis of the images would allow the system operators to detect emitted radiation. The

more intense the radiation, the more the digital movie would be distorted in ways that the human eye cannot see but which could be detected by the computer programme which could issue an alert automatically. In addition, a timestamp and GPS location could be stored. The user could be asked to run the app at least twice from slightly different locations to enable the system operators to determine the source strength. Central automated analysis in the database, which could use the data of more than one user, would generate an alert for the system operators. The person reporting (i.e. running the app) should not receive automated feedback on radiation readings. As a result, the system would be useless to a hostile person who might want to find and use nuclear material. It would also enable the system operators to manage information securely while providing safety advice to a friendly person in a way that avoids creating panic. Users would be asked for permission to run the app in the background from time to time. Combining the information of many users would allow the system operators to detect areas with slightly elevated background radiation, which could be generated by dumped waste, uranium ore deposits or stolen uranium ore. The app could enable anyone with a smartphone to report an initial assessment of the possible presence of uranium ore or nuclear waste and then move away if on land or, if at sea on a fishing boat, drop the object back into the water which would act as a radiation shield before the system operators come to assess it. Enabling participation could enhance public trust in the project and buy-in. In addition, the app in effect massively broadens the potential survey area to include anywhere that someone has a smartphone. Somalia has excellent network coverage. Even if the person does not have access to the network at that particular moment, the app could be designed to upload automatically once the phone is within network coverage.

Creation of capabilities to survey for or evaluate reports of the presence of radiological material

The system operators should have capabilities to carry out surveys based on documentary or interview evidence, sensor reports, mobile phone app alerts or other reports such as word of mouth to determine conclusively whether dumped nuclear waste or illegally obtained uranium ore is present. When arriving close to a standard survey area or suspect area on land, the system operators could monitor the radiation they are exposed to using a Geiger counter. They could then start surveying the area using an aerial drone with a radiation mapping payload. This would allow them to assess the

suspect object or area from a safe distance. The payload should also contain a camera for visual inspection. The system operators should also have a radiation mapping backpack for surveying on foot. If it was safe enough, the system operators could go closer and gather forensic evidence in the form of photos and samples. All data from all surveys and inspections could be sent in real-time to the secure, central database which should also be used for the mobile phone radiation dosimetry app. For suspect objects in the sea the system operators could use underwater drones with an optical tether which would allow deployments of more than 500 metres from the operator. The system operators could be provided with a positioning system involving dead reckoning based on the use of GPS (for when at the surface) integrated with pressure/depth sensors and inertial measurement units and supplemented either by a smart-tether system or smart buoy.

Possible expected results

If the system we propose here were to be deployed, we would expect that the following results would be possible:

- Claims of past nuclear dumping in Somalia or off its coast could be evaluated.
- If nuclear waste was located it could be secured and cleaned up, with benefit to the population and the environment, and the basis laid for possible identification and prosecution of perpetrators. The claims and information related to health symptoms, disease, and cancer could be followed up on by researchers and health agencies through bio-monitoring and epidemiological investigation to understand health and disease outcomes over the long-term. Establishing cause and effect relationships would require specific sub-population and population level monitoring and analyses.
- If surveys of relevant locations uncovered no evidence of the presence of nuclear waste, the public and others in Somalia and beyond could be reassured.
- Putting in place covert monitoring of Somalia's uranium ore deposits could assist deterrence, detection and prevention of illegal, unauthorised movement of such materials for nefarious purposes such as smuggling for export or for use in a dirty bomb.
- The system as a whole would be a vital element of a credible IAEA-approved nuclear security regime as part of Somalia's steps towards becoming an IAEA member.
- Such a capability would be a substantial symbolic and practical contribution to the functioning of the state.

- The record of likely and proven intent to dump nuclear and other toxic waste on Somalia has generated a strong desire among Somalis to be able to regulate their own environment in relation to nuclear issues, and the system we suggest would enable that.
- Somalis feel themselves to be the victims of past direct colonialism and more recent 'toxic colonialism' (Hussein, 2010a, 4). This manifests itself in resentment at the deployment of the naval forces of other countries to stop piracy while neglecting IUU fishing and possible toxic including nuclear waste dumping. The international cooperation required for the system we suggest would help to overcome that resentment by addressing some of the reasons behind it.
- The infrastructure of the nuclear security system we suggest could, with due attention to avoiding potential downsides, have wider humanitarian and development applications, such as mineral, agricultural or wildlife surveying, or delivery of medical supplies to hard-to-reach locations, so that it would not sit idle when not engaged in nuclear security duties.
- The system could be adapted for the nuclear security and wider development needs of other low-income countries.

In sum, a nuclear security system for Somalia of the kind we are suggesting has much to recommend it.

Conclusion

We have reviewed the recent history of Somalia with respect to nuclear materials and concern regarding their potential use in dirty bombs. This history and concern have prompted us to suggest a methodology and system to assess the various possible instances of smuggling, illegal movement of uranium ore and credibility of claims of nuclear waste dumping. The innovative nuclear security system proposed in this article addresses all four nuclear security issues faced by Somalia – the lack of an IAEA nuclear security regime; its vulnerability to uranium ore smuggling from its currently unsecured uranium deposits; the potential use of its uranium ore by terrorists in a dirty bomb; and its current inability to address past possible occurrences and current vulnerability to being used as a site of nuclear waste dumping on land and offshore. Somalia is making efforts towards establishing an IAEA nuclear security regime, supported by the IAEA. However, those efforts cannot get far without the technical capabilities necessary to underpin them. The system we suggest here is tailored

to Somalia's specific needs, desires and circumstances. At present, Somalia has substantial uranium ore deposits near the surface in Galmudug FMS which have not been secured and which are not even monitored. The system we suggest for uranium ore fingerprinting, static tamper-proof sensors with automated alerting, crowd-sourced reporting using a mobile phone app, plus aerial and underwater drone surveying and evaluation is an innovative, low cost design. It would provide integrated monitoring of uranium ore deposits and an ability to assess possible remnants from nuclear waste dumping on land and at sea. The system we are suggesting is not merely a technology-driven niche activity aimed at something marginal to the lives of Somalis; it speaks to a visceral, emotional aspect of identity, dignity and decolonisation. The infrastructure that would be created could easily be augmented for wider development purposes and has the potential for adaptation to other low-income country contexts.

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