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Using Non-Intrusive Geophysical Surveys to Combat the Lasting Legacy of War on Laotian Agriculture

Laos' title of "The Most Heavily Bombed Nation in History" is reflected by the substantial amount of unexploded ordnances (UXO) that pose a threat to Laotian civilians daily. UXO are "any object containing explosives of any kind which has been deployed and failed to detonate, or has only partly detonated, or such objects which have been abandoned in any condition" (McGrath 19). The high density of UXO scattered throughout the nation hinders the country's development, resulting in food insecurity for subsistence farmers. How did Laos reach this point where farmers face the problem of risking their lives or losing means of sustenance due to contamination by UXO?

In the predominantly rural country of Laos, families heavily depend on agricultural activities at the subsistence level; rice cultivation and animal husbandry are primary sources of sustenance and supplemental income (The World Bank [*Lao Rural*] 4). With more than half of households earning an annual income below 300 USD as subsistence farmers, poverty is an issue that threatens many rural families (Ambrosio Barros et al.). Thus, food security and malnutrition remain a problem, with approximately 23% of households experiencing severe food insecurity (Chun). In the Northeastern region of Houaphanh, in Laos, a study of 20,000 children showed about 13% were malnourished (Whong). This is the same case for many other remote regions in Laos, where residents find it difficult to properly have nutritional and balanced meals.

A root cause of food insecurity is Laotian farmers being prevented from fully utilizing available agricultural land in fear of possible UXO contamination. During the Vietnam War, President John F. Kennedy approved the bombing of the Ho Chi Minh Trail, a supply route that aided in the infiltration of supplies and troops from communist-led North Vietnam into South Vietnam ("JFK in History"). More than two million tons of cluster bombs were dropped on the Ho Chi Minh Trail, and roughly a third of the 270 million sub-munitions have failed to detonate ("Laos"). Accidents concerning UXO in Laos are frequently caused by farming, cutting grasses and vegetation, and digging land. (Bottomley and Sauvaly 26) Thus, remaining bombs have hindered the country's long-term agricultural development with around

twenty-five percent of the potentially farmable land not being used due to potential bomb contamination (Pinkel). In early 2007, rice farmer Por Vandee and his family faced the consequences of UXO contamination while farming a few miles from their village. While planting rice with his wife and three children, his son's hoe struck an UXO. Later, once awoken, he found out that two of his sons were dead and the other had brain injuries (Clarke). Decades after the Vietnam War, the bombs that remain not only prevent people from using land and accessing basic services but also instill fear of possible injury or death.

In addressing this challenge of UXO contamination, foreign aid from other nations was embraced as a prominent measure. Efforts have been made to remove bombs by the United States to fulfill their moral obligation after inflicting the problem during the war. In 2016, President Obama visited Laos, the first American president to do so, hoping to establish a partnership. In his remarks, he promised that the "partnership will continue to deal with the painful legacy of war" and "double [the United State's] annual funding to $90 million over the next three years to help Laos expand its work…to remove even more bombs, allow Laotians to farm more land, and increase support for victims" (Obama). However, the funding does not adequately compensate for the problem; the U.S. spent $16 million per day for nine years bombing Laos but averaged an annual contribution of only $4.9 million for UXO clearance in Laos between 1993 and 2016 ("Legacies Library"). Even with funding from the United States and other nations, the Laotian government's chronic fiscal deficits also further slow the progress of disposing of UXO (Inoue).

In Vietnam, where the war also had similar results of UXO contamination, military units are often used to excavate an area. During the Ho Chi Minh Highway construction, the military undertook the largest demining project, in which 2 percent of the total costs ($10 million) was spent on clearing UXO, far exceeding the budget ("Vietnam"). In addition to the help of the People's Army of Vietnam, international organizations have funded site clearance projects in Vietnam. An American organization, PeaceTrees Vietnam, removed over 110,000 dangerous UXO from over 2,810 acres of land since 1995 ("Humanitarian Mine"). One of the largest international clearance agencies, the British organization of Mines Advisory Group (MAG) worked alongside the national authorities and the government of Vietnam to excavate millions of square meters of land, which are now open to be used for infrastructure crucial to the development of the community ("Vietnam").

Similarly, Laos has received help from international organizations, namely MAG, which sought to minimize the effects of UXO in Laos through education. The organization has held over 486 risk

education sessions, dedicating itself to helping Laos recover from the impacts of war ("Laos"). The use of mass media, specifically posters, has helped spread to both locals and foreigners the dangers of UXO. The posters created by MAG range from warning children not to disturb bombs when found to advising farmers to be vigilant when farming.

Through the Laotian government's partnership with several development organizations, many UXO clearance programs have been undertaken, resulting in positive changes. Over the last decade, the number of UXO casualties has been reduced by 85% and less than 50 casualties have been reported annually (United Nations in Lao PDR). This is a significant improvement from the number of casualties seen in recent decades after the war (1974-2007), where numbers remained above 100 (Clarke). Alongside the success of UXO clearance, Laos underwent great economic growth, as well as improvements in food availability. From an alarming Global Hunger Index score of 44.2 in 2000, it increased to a moderate score of 19.2 in 2022 ("Lao PDR"). Despite such improvements, disparities still exist as rural communities receive inadequate support regarding food security. It is critical to find a way to mitigate the impacts of conflict and continue to support the agricultural sector sustainably in Laos.

Non-intrusive geophysical surveys are frequently used to identify and then map out potential UXO before professional excavation. Non-intrusive geophysical surveys use different types of technologies to locate buried UXO without physically disturbing the ground, minimizing potential threats from explosions. Magnetometry, electromagnetic induction, and infrared sensors are just a few technologies utilized to characterize UXO, and they all vary in terms of the types and depths of UXO it can measure, the topography it can be used on, and overall effectiveness (US Army Environmental Center 7). Combining two or more of these sensor technologies allows for the optimization of data collected, resulting in effective planning of excavation while also ensuring safer farming practices.

Magnetometry involves identifying anomalous magnetic field intensities caused by iron-based substances in the ordnance ("Magnetic Method"). Geophysical surveys using magnetometry are usually conducted with hand-held magnetometers, which then render maps of the magnetic field intensities in a grid pattern. The earth’s magnetic field is constantly susceptible to change, thus monitoring the fluctuations is required to accurately collect data. Another shortfall to this survey method is that the magnetometers only respond to ferrous objects and fail to locate non-ferrous metallic objects.

Electromagnetic (EM) induction involves the use of electric currents through the surface of the earth and the measure of the metals’ response. Electromagnetic methods, specifically GPR (Ground Penetrating

Radar) systems, are often affected by the condition of the test sites, such as the topography or vegetation (US Army Environmental Center 8). Generally, EM systems must be positioned close to the ground to detect both ferrous and non-ferrous metals near the surface of the soil.

Finally, infrared sensors use thermal energy to identify objects, but only under the condition that there is a contrast between the thermal energy of the UXO and its surroundings. While the geophysical survey methods of magnetometry and EM induction were reported to have a UXO detection rate of 50-83% and 11-85%, respectively, infrared sensors had an unknown rate (US Army Environmental Center 8). To reduce the margin of error, it is best to use two or more of these sensor technologies in conjunction. With the use of magnetometry technology combined with that of an EM induction, it was found that the detection rate of UXO was 65-72% (US Army Environmental Center 8). The average detection rate rose significantly and ensured higher chances of success.

Such technology can be applied to create an accessible instrument that geographically surveys the land, combating the issue of food insecurity due to UXO contamination in Laos. The use of both magnetometers and EM systems allows for the detection of both ferrous and non-ferrous metals at various depths, and their data can be used to corroborate each other (Han et al. 4). Thus, both methods can be used to create a collective database of buried UXO which can: map out areas to avoid, alert farmers of its location through communal monitors, and contact military personnel immediately for excavation. The Department of Agricultural Land Management of the Ministry of Agriculture and Forestry (DALAM) is in charge of conducting research and carrying out surveys to properly manage and develop agricultural land across Laos ("The Department"). Through the department's funding, a map with the specific location of UXO, as well as its radius of danger, can be rendered. Such maps would be displayed in public areas through monitors, as well as on tablets owned by each farmer to ensure accessibility by all of those who live in rural communities. This allows not only farmers but also the general community to avoid certain areas while farming. This system is built around the effectiveness of UXO detection technology and communication, establishing a gradual process that allows for more uncontaminated arable land.

1st Line Defence, an accredited UXO risk mitigation company, follows a certain procedure for non-intrusive surveys that can serve as a reference to this proposal. The non-intrusive UXO survey is executed by a specialist two-person team, where a detector system is either walked or vehicle-mounted and towed across the land. This ensures that the ground isn't disturbed and a large amount of land can be surveyed effectively. Data collected from the survey is logged and sent back to a geophysical team for processing and interpretation, producing a false color map that highlights ferrous anomalies. The data is

further reviewed by specialists to uncover other items that present potential harm; the company also outlines potential risks and further specialist support that is required onwards. ("Unexploded Ordnance").

However, 1st Line Defence is a company based in the United Kindom, where digital resources are more accessible to the general public. In order for this proposal to be carried out in Laos, digital connectivity is a key component. Laos has been lagging in terms of accessibility, quality, and affordability of internet services. ("Digital Connectivity"). While about 80 percent of the population is now covered by the fastest available mobile broadband networks (4G/LTE), this does not necessarily equate to access. The quality of mobile broadband varies significantly within the country with mostly rural communities receiving poor quality access. Affordability also is a challenge for many since the lowest entry-level monthly mobile data package is priced above the ITU-UNESCO affordability threshold of 2 percent of income per capita. (The World Bank [*Positioning*] 45). To improve citizens' access to high-speed and high-quality internet, the Ministry of Technology and Communications of Laos (MTC) can enforce price regulations as well as facilitate infrastructure sharing between network operators. Laos's advancements in digital connectivity can allow for greater accessibility of the database that contains mapped-out UXO.

This proposal would provide desperately needed arable agricultural land to Laotian farmers in UXO-contaminated areas. The historical consequences of war have provided a long-lasting legacy to the agricultural activities of Laos and continue to do so. Efforts have been made since the war by the Laotian government and external organizations that provided funding for UXO clearance projects. However, Laos is still in need of a solution that further mitigates the consequences of war in a sustainable manner. The application of non-intrusive geophysical surveys, especially the use of both magnetometry and EM induction, to create a database would substantially benefit the agricultural sector in Laos. Not only would it increase food security by efficiently increasing crop yields, but it would also increase agricultural output and overall economic development in rural communities, as well as the entire nation. Though this solution does not bring an absolute end to the agricultural problem in Laos, it is indisputable that the solution will allow for the expedited recovery of Laos both historically and agriculturally.

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