**D1 Project Description**

**PROJECT TITLE:** *Agricultural shocks and early warning of conflict*

**PROJECT QUALITY AND BENEFIT**

**Problem**

How can we predict when, where, and how conflict, and conflict-driven food insecurity will occur after agricultural shocks? Agricultural shocks from external factors such as weather, trade blockages, and increased prices, tend to have an important impact on the livelihoods of those who live on a tight budget and who rely on income from agriculture. Where the rule of law is weak, and governance is sub-optimal, such external shocks may lead to social unrest and even escalate into more violent forms of conflict. Southeast Asian countries, for instance, often see high levels of agricultural conflict in many forms. In the Philippines alone, since 2016, there have been more than 10,000 reported incidents that involved an armed altercation or violence of some sort. There were nearly 50,000 such incidents in the whole region in the same period. Among incidents of an agricultural character, many have been fueled by drought, trade blockages, or unfavorable rice prices, which have led to protests demanding some sort of support to farmers, as well as more violent altercations.

The conflicts themselves may also lead to market disruptions and food scarcity, which can result in knock-on conflicts elsewhere. The ongoing Russia-Ukraine conflict, the destruction of Ukrainian food production and blockage of exports, and the knock-on effects on food insecurity are illustrative of the challenges connecting agriculture and conflict. Many countries dependent on Ukraine grain, such as Niger, Mali, Papua New Guinea, and Myanmar already have issues of instability within their borders (Institute for Economics and Peace 2022). Understanding the mechanisms by which agricultural shocks might lead to conflict, and how conflict may in turn lead to food insecurity is vital for understanding the effects of agricultural shocks, and for providing early warning of situations relevant to Australian security where conflict might break out.

**Aims**

The project will use granular data and sophisticated econometric techniques to (1) **shed light on the mechanisms and regularities in the relationships between agricultural markets,** particularly shocks in markets as measured by prices, outputs, and barriers to trade**, and local and international conflict**. This will allow for (2) **modeling the effects of food scarcity (or surplus) on local and global conflicts, and the effects of conflicts on food security**, thus providing an early warning system for the Australian Government to assess conflict risk and conflict-based food insecurity in strategic regions.

**Background**

In low–income economies with weak institutions and high agricultural dependence, a change in people’s income may exacerbate a whole range of unlawful or violent activities. The relationship between climate and conflict has attracted a large literature (von Uexkull & Buhaug, 2021), although the actual pathway between climate shocks and conflict onset (or changes in conflict intensity) is often indirect or ambiguous (Buhaug, Benjaminsen, Sjaastad, & Theisen, 2015). Bad harvests or drops in crop prices can be important sources of negative income shocks in regions where agriculture is an integral part of the economy. Moreover, as opposed to general climate events, empirical evidence points to a strong linkage between crop yields and conflict (Wischnath & Buhaug, 2014; Buhaug et al., 2015; Koren and Bagozzi, 2017; Koren, 2018; Vestby, 2019) as well as commodity prices and conflict (Dube and Vargas, 2013; Maystadt & Ecker, 2014; Raleigh, Choi, & Kniveton, 2015; Berman and Couttenier, 2015; Fjelde, 2015; Crost and Felter, 2020; McGuirk and Burke, 2020).

The mechanism by which agricultural shocks might lead to conflict can be reduced to a several theories. One is the so-called *opportunity cost* mechanism, which suggests that an individual has an option to farm or to fight, whereby income from the former is an opportunity cost of the latter. The opportunity cost of fighting is seen as an increasing function of income—a negative income shock leading to more violence (Collier and Hoeffler, 1998; Bazzi and Blattman, 2014). The individual will choose the former over the latter if expected benefits outweigh the costs, otherwise (e.g., if it is a bad crop year, or the commodity prices have dropped) the individual may consider less peaceful ways of generating income. Alternatively, a drop in farm income reduces the value of spoils to be appropriated, which can mitigate violence (Berman and Couttenier, 2015). The other is the *rapacity* mechanism, which suggests that perpetrators are more likely to engage in conflict when there is more at stake (e.g., after a good harvest season, or when the commodity prices are high). These two mechanisms are potentially offsetting in their impact on conflict incidence. The net effect of income shocks on conflict is thus ambiguous as illustrated by a large body of literature on the topic (Blair et al., 2021). However, a careful examination of the data, including the timing of the conflict relative to the crop marketing season and other agricultural shocks, as well as the forms of conflict and the types of the perpetrators involved, can help disentangle the unique forces that facilitate each of the two mechanisms.

McGuirk and Burke (2020) show, using geographically disaggregated grid cell–level data, a positive and statistically significant relationship between cereal crop prices and conflict. More specifically, they define two broad categories of conflict, *factor conflict* and *output conflict*, based on actors’ motivations. Factor conflict involves actors engaging in battles for control of a territory to seize its discounted expected returns. This type of conflict tends to be long lasting. The aim of output conflict is to appropriate surplus. This type of conflict, compared to the factor conflict, is more transitory.

Conflicts that can be linked with farm income might fall into the output conflict category for several reasons. First, agriculture is a labor–intensive sector, with large–volume and low–value output. Thus, ‘rent–seeking’ may not necessarily apply in this sector (in contrast to the diamond mining sector, for example). Second, agricultural output is a readily available source of food and feed, and thus is an attractive target for conflict actors that are attempting to extract resources without controlling territory (e.g., Koren and Bagozzi, 2017).

At the heart of the question of the link between agricultural production and conflict is not only the *mechanism* by which income shocks lead to conflict intensity, but also *who* is engaging in violence. The *identity* of the actors involved in that increase in conflict would vary based on the goals and motivations of the actors – actors that are engaged in output conflict would be more likely to increase their attacks at certain times (such as during the harvest period) than groups engaged in factor conflict. In the ACLED data project, conflict actors are divided into four categories, depending on who is supporting them, and the nature of their goals (Raleigh et al, 2010) – state forces, rebel groups, political militias, and identity militias. While there is significant overlap, these different conflict actors vary in the location, targets, modality, and fatality rates of their violence (Raleigh, 2012; Raleigh & Choi, 2017; Choi & Raleigh, 2021). Rebel groups engaged in civil wars are likely to attack mostly state forces (although they also attack civilians) over a relatively long period of time, in areas that are dominated by politically marginalized, large groups. Identity militia violence may occur in politically marginalized areas, operating on behalf of politically marginalized groups that do *not* have the resources to create organized rebel groups. Violence may be directed against other identity militias, or against civilians in opposing ethnic or regional groups (Raleigh, 2014).

Thus, while climate taken as a whole might have an ambiguous effect on conflict, agricultural shocks are more amenable to finding linkages with conflict. An effective early warning tool that links how agricultural shocks lead to conflict, and how conflict in turns leads to food security, requires an understanding of what the likely effects of agricultural income and yield are, who the potential conflict actors, what types of conflict they are engaging in.

**Importance and innovation**

The relationship between agriculture and conflict is a fundamentally interdisciplinary question. The research will synthesise the issues pertinent to climate science, agricultural economics, and conflict studies in political science. In doing so, the research will draw on the literature in all three dimensions, with emphasis on careful econometric analysis of the increasingly dense data on location and timing of conflict incidents, specifically in relation to crop harvesting season and weather and price shocks in that period, that can vary from year to year and across locations. The project, thus, will generate fruitful soil for future interdisciplinary work, as well as a platform for the disciplinary advancement of the knowledge in the respective fields.

Conflict is both a consequence and cause of dysfunctional institutions. It distorts normal functioning of the state by overwhelming its capacity, which has dire consequences for the society. It also increases the risk and acts as a transaction cost for proper market functioning. Both these factors deviate the economy from its social optimum. By examining the economic origins of conflict in developing countries, we will present an explanation of the role that food prices and availability, and the agricultural sector might be playing in the process, and we will offer a policy perspective and forecasting tool that could help mitigate the issue.

A distinctive feature of agricultural production—and, therefore, of agricultural income—is its seasonality. Conflict, due to intermittent employment in the agricultural sector throughout the marketing year as well as the abrupt influx of income shortly after harvests, is likely to also have a seasonal pattern. In examining the relationship between agricultural income shocks and conflict, previous studies have relied on yearly conflict and price data observed either at the country level (e.g., Miguel et al., 2004; Brückner and Ciccone, 2010; Bazzi and Blattman, 2014), or at the grid cell level (e.g., Fjelde, 2015; Berman and Couttenier, 2015; Berman et al., 2017; Harari and Ferrara, 2018). These yearly estimations represent the average effect and may conceal important seasonal patterns. The few studies that have worked with monthly data, have not specifically examined the role of seasonality in the income–conflict nexus (e.g., Maystadt and Ecker, 2014; Smith, 2014; Bellemare, 2015).

While offering evidence of a linkage between agricultural income and conflict, these studies, by design, do not investigate the important seasonal variations in this relationship, and thus do not capture the role of the harvest itself in conflict. Causes of conflict can be multifaceted. They can be linked to resources (e.g., access to the irrigation system, machinery, etc.) or to output (e.g., ambushing farmers as they secure the harvest or as they transport the harvested commodity to markets). By empirically examining, using econometric methods, conflict occurrence vis-à-vis the timing of food production, its harvest, and marketing, this research will contribute to the emerging literature on the seasonality of conflict, resulting in an ability to explain and predict conflict based on seasonal changes in food prices.

The availability of spatially granular data has allowed researchers to carefully examine economic origins of conflict. They have found, for example, that conflict is more likely near the diamond mines, or where cash crops (e.g., cocoa, bananas) are predominantly produced (e.g., Berman et al., 2017; Crost and Felter, 2020). Our project will advance knowledge in two key dimensions. Firstly, it will track and show the seasonal pattern of conflict based on food prices, which is crucial in agrarian societies. Secondly, it will allow us to investigate less studied agricultural aspects of conflict (e.g., fights over the irrigation water rights, or machinery during planting and harvest seasons).

**Approach**

In approaching our problem, we develop and then apply a conceptual framework that links rigorous time series analysis of shocks, food prices, agricultural yields, and market integration with causal pathways, and an understanding of the conflict environments in states in regions of strategic interest to Australia. The framework is part of a five-fold approach, as illustrated in Figure 1.

1. We look at agricultural shocks as measurable events that can have negative *or positive* effects on agricultural output and the ability to transport that output. Adverse climate events such as excessive rainfall (through cyclones or flooding) or drought can lead to changes in agricultural yields, and disrupt food transport networks. In a feedback mechanism, local conflict can also disrupt harvests or transportation, or divert food supplies. On a seasonal basis, the harvest itself generates a positive agricultural shock, in terms of the size of the available food supply, as well as income which itself create the potential for conflict, as conflict actors seek either to requisition that income or destroy it to harm their enemies.
2. These agricultural shocks can influence local conflict directly, through the ensuing competition over scarce or abundant resources, or through their effect on prices. While the existence of shocks is not particularly difficult to figure out, measuring their effect is less clear. Their immediate effect on people’s welfare can often be seen most directly through changes in price levels. We thus use prices in several ways. First, changes in prices can lead to conflict: price increases may indicate shortages or disruptions to the supply chain, while price decreases may indicate a loss of income for potential conflict actors. Price changes thus serve as an early warning for conflict.
3. At the same time conflict can have effects on food security. First, conflict can lead to changes in price through disruption of supply chains. Second, conflict can directly affect agricultural outputs through dislocation of populations and destruction of crops. Third, conflict can lead to changes in the spatial configuration of prices, and thus the integration of markets within a country, and between countries (Hastings et al, 2022). Such impacts can have direct effects on domestic demand and lead to changes in import/export profiles of a country’s agricultural sector. This can have long term effects that are difficult to recover from and that create future food security issues. For example, a decrease in domestic demand can lead to a loss of wages in the agriculture sector. This makes the sector less attractive as an employer, making it more difficult to source future workers. This not only can lead to a loss of yield, but also represents a drain of knowledge and skills for future harvests.
4. Local conflict flowing from these shocks have a number of characteristics, which are derivative of the nature of the relevant agricultural shock. The *location* of the conflict may shift depending on areas of crop production or distribution, or control by different conflict actors. The *conflict actors* involved are also likely to change depending the location of the conflict, the seasonality of the conflict, and what is being fought over, based on our ongoing research. The *conflict type* is also likely to vary depending on the type of agricultural shock and the type of conflict actors – for example, political militias may be more likely to attack civilians in short spurts of violence than rebel forces, which may focus on attacking state forces in long-term campaigns (Raleigh and Kishi 2020).
5. Coming from outside the feedback loop, we can think of international conflicts as directly influencing local conflicts, for example, through spillover of conflict actors, or drawing in third countries to the conflict directly, either militarily or economically, or inducing agricultural shocks. The onset and course of an international conflict may disrupt international food or fertilizer supply chains through destruction of the harvest or through sudden, unexpected barriers to trade, with the specific countries affected determined by the spatial configuration of the supply chains, as measured through trade data.

**International conflict**

Sudden barriers to trade

Destruction of agricultural outputs

**Price**

Levels

Change in levels

Integration across territory

**Agricultural output shocks**

Positive supply shock (seasonal harvest)

Negative supply shock (climate events, conflict)

**Local conflict**

Attacks on civilians

Intrastate conflict

Riots/Protests

*Figure 1. Diagram of links between agricultural shocks and conflict*

**Methodology**

Using the approach above, we build an early warning model that can take indicators of agricultural shocks – changing local and international commodity prices, changes in agricultural yields, and disruptions to global or local food supply chains – and establish, through plausible causal pathways, links to onset, intensity, and geographic locations of different types of conflict by different types of actors. We then use past data from two strategic regions – Southeast Asia and the South Pacific – to provide a proof of concept for the model, fitting past data, and forecasting future conflict based on food insecurity.

*Data*

This project will combine spatially granular data on conflict with high frequency data on food prices and production seasons across different countries to investigate potential agricultural roots of conflict. IEP, as a matter of its operations, keep a regularly maintained database of conflict and related indicators at the national, subnational and granular gridded levels. This includes two primary sources of high frequency conflict data. The first is the well regarded Armed Conflict Location & Event Data (ACLED) compiled by Raleigh et al. (2010). This dataset is highly granular in the sense that: (i) it features any reported conflict regardless of whether the altercation resulted in any casualty; (ii) it groups incidents into six categories, which include battles, strategic developments, and explosions/remote violence that feature two parties, typically the state or state-affiliated militias and the rebels, that dispute the control of a territory, it also includes violence against civilians perpetrated by any of the paramilitary groups, as well as protests and riots that feature different manifestations of public disorder of some sort. IEP’s database also receives daily updates of events that are classified as terrorist activity across the globe. This dataset is from Dragonfly, a UK based organisation, and classifies attacks by weapons used, targets and motivation. IEP also has all of the UNCP datasets. These suites of sources allow for cross referencing for quality control of input data.

We will collect data on food prices from multiple sources. International prices are available via the International Monetary Fund’s Primary Commodity Prices portal, and the World Bank’s ‘Pink Sheet’ portal. Additionally, city or region-level prices are available through Global Information and Early Warning System of the Food and Agriculture Organization of the United Nations, and the World Food Programme of the United Nations.

We will source the data on cereal grain production and harvest months from Sacks et al. (2010) and Monfreda et al. (2008). IEP also stores gridded data on crop yield of rice, maize, soybean and wheat from 1981 to 2016 (Iizumi and Sakai, 2020). We consider two key cereal grains produced across Southeast Asia and the South Pacific: rice and maize. While rice is, by far, the most dominant cereal—both in terms of production as well as consumption—in a select few locations, maize is the more cultivated crop.

IEP sources and stores high-frequency weather data from the Copernicus Project (Hersbach et al., 2018). Of relevance to our project are the ERA5 reanalysis data on gridded daily 2 meters-above-surface air temperatures and monthly averaged total precipitation, collected across multiple years for the period spanning the crop growing season. In addition, we will consider changes in large-scale medium-frequency climate events, such as El Nino Southern Oscillation, that greatly impacts weather patterns in the Southeast Asia and the South Pacific. We will obtain these data from the online portal of the National Oceanic and Atmospheric Administration.

To provide a broader context to the analysis, IEP also has subnational data on societal resilience data on health, wealth, education and inequality at the subnational level. IEP also maintains a large database of national level indicators on socio-economic and political indicators. These overarching variables provide a globally comparable ground set of underlying social drivers and shocks that can contribute to conflict (IEP 2022).

*Research plan*

1. Development of early warning tool connecting agricultural shocks and conflict (Year 1)

The early warning tool will be developed and honed by the project’s multi-disciplinary team in agricultural economics and political science to clarify the mechanisms connecting agricultural shocks and conflict. We will model the effect of agricultural output shocks, both directly, and with prices and market integration as intervening variables, on conflict, which will be the primary outcome of interest, and bring in models of conflict’s effects on agricultural output and supply chains. We are specifically interested in (1) conflict intensity (as measured by number of incidents or number of casualties), (2) locations and shifts in conflict within and between countries, (3) type of conflict (for example, attacks on civilians, riots or protests, armed clashes, terrorism), and (4) identity of conflict actors, to include state forces, rebel forces, political militias, and identity militias (Raleigh et al, 2010).

Agricultural shocks as the root cause of conflict. We will employ state of the art causal inference methods to examine the relationship between agricultural shocks and conflict. We define agricultural shock as an exogenous change in agricultural output (e.g., drop in production due to unfavorable weather conditions) or in value of agricultural output (e.g., increase in revenues from selling agricultural surplus due to rising international prices). The use of exogenous factors, in this setting, is crucial as a change in agricultural output, in and of itself, may very well be endogenous to conflict. Most prominently, reverse causality is very likely in the income-conflict nexus. For instance, there may be negative relationship between agricultural production and conflict either because when the “farming” doesn’t pay, a subset of population opts for “fighting” as the next best alternative (the so-called opportunity cost mechanism), or because when conflict happens the normal production processes and distribution channels are disrupted, leading to less agricultural goods on the market (which we allude to below). Both directions of the causal mechanism are of interest to this project.

In measuring the effect of agriculture on conflict, we will use changes in local weather and in the international commodity prices as instrumental variables, to identify the effect of agricultural output (or value) on conflict. Specifically, the modeling framework, in general terms, will be as follows:

(second stage), where

(first stage).

Here, the parameter of interest is , which we identify by instrumenting the potentially endogenous agricultural output (or agricultural value), labeled ‘agriculture’ in these equations, with local weather or international prices., labeled ‘shock’ in these equations. Control variables will include location and time fixed effects as well as any relevant covariates (e.g., size of the population in the region).

The foregoing framework can be augmented in several directions. One direction is in linking the seasonal pattern of agricultural employment and agricultural output on intra-year patterns of conflict. Examining such patterns, referred to as the seasonality of conflict, is a relatively recent development in the literature on economic roots of conflict, partly due to the increasingly available granular data on conflict. The benefits of examining the seasonal patterns of conflict, in relation to agricultural shocks, are two-fold. First, this allows for a more accurate estimation of the relationship between agricultural shocks and conflict. Second, to the extent that the harvest season is pre-determined, albeit with minor variations of exact dates from one year to another, it allows for the designing of a model that can be easily applied for predicting the temporal changes in violence, thus serving as an important component of the early warning system.

Conflict as the transaction cost in market integration. To measure the level of market integration across markets within a country’s territory, and between countries, we will build on the law of one price hypothesis in the spatial context. The basic principle of this hypothesis suggests that prices of the same commodity in two spatially separated markets will co-move if the commodity can be transported between the markets. Otherwise, price dynamics in the two markets are likely to be disentangled. Several factors can disrupt market integration, and therefore price transmission, between two markets. The “usual suspect,” for example, is the cost of transportation. But other factors can also contribute to the transaction costs. One such factor may be conflict (e.g., Hastings et al., 2022).

To briefly illustrate the point, consider a pair of markets, denoted by and . Let the prices in these markets in period be and , respectively. For simplicity, suppose the transaction costs are paid in form of a barter. To that end, we can introduce the so-called “leakage” factor, , which is a share of the commodity that is lost during its transportation from to . Thus, the further apart (typically geographically, but also politically, institutionally, etc.) are the two markets, the higher are the transactions costs, and the closer is to one.

The concept of “leakage” is particularly well-suited for locations where conflict or social unrest is not unusual. There, there may be a good chance that either armed forces or rioters seize some or all the cargo from an arbitrageur, leading to the partial or complete leakage. Regardless of the source of leakage, the per-unit profit of an arbitrageur from to is given by . It follows that the no profitable arbitrage condition is given by . Similarly, the no profitable arbitrage condition from to is given by . In these arbitrage conditions, captures all the transaction costs, including a normal economic return for all the work involved in the process. Combining the two inequalities, and taking natural logarithms gives the so-called transactions costs band: . Thus, if the log price differential, in absolute terms, is less than , it is not worth an effort and a risk for arbitrageurs to engage in trade; otherwise, the trade will happen, and we will observe adjustment in the prices. Put differently, using this modeling framework, we can identify the levels of social unrest or conflict intensity that can become detrimental in normal functioning of markets. The reverse causal loop can also be incorporated to capture the secondary effects of conflict affecting the food system.

2. Application of early warning tool to strategic regions (Year 2)

The two proof-of-concept regions for application of the early warning model – Southeast Asia and the South Pacific – were chosen for several reasons. First, they are two of the regions of greatest strategic interest to Australia, inasmuch as they form the ‘near abroad,’ with other powers competing for influence within the region, extensive trade, political, and military links between Australia and countries within those regions, and persistent challenges for Australian security. Second, and relatedly, both regions are prone to flare-ups in conflict that have drawn Australian government responses over the past several decades – for example, East Timor in the 1990s, and the Solomon Islands as recently as 2021.

Third, each region provides different contexts for the causal between agricultural shocks and conflict. While they engage in substantial subsistence food production, countries in the South Pacific are dependent on fragile trade networks for sufficient food supplies. As such, food insecurity may be caused by disruption of trade, or collapses in agricultural yields. By contrast, unlike Africa, which is dependent on rainfall-fed agricultural production and relies on food imports, Southeast Asian countries are generally food exporters, with some of the most competitive economies in the world for agricultural exports (Mizik et al, 2021). Aside from climate events, food insecurity may arise from local conflicts that disrupt supplies or production, or conflict may arise from trade blockages or high food prices, even in food-producing regions. Both Southeast Asia and the South Pacific are also severely understudied relative to Africa in research on links between climate and conflict (Adams et al, 2018), meaning that two of the most important regions for Australia are blind spots in our understanding of climate- or agricultural shock-conflict linkage. Taken together, these regions provide an ideal context for establishing proof-of-concept application using rich data.

The tool will be applied to these areas, both as a proof of concept using past data, and to forecast food insecurity and conflict areas. Although we will look at all countries in the regions, we will focus especially on Cambodia and Philippines and Papua New Guinea and Fiji, given data availability and/or strategic relevance. The models will be run using past data for these countries. We will then conduct out-of-sample forecasting, and compare with data for fit. This will result not only in a proof-of-concept for the early warning tool, but also an understanding of what variables are relevant for predicting agricultural shock-related conflict, allowing us to iteratively improve the accuracy of the model. The case studies will also tell us which data would need to be collected in the future to build accurate indications of coming conflict and food insecurity.

3. Dissemination of results (Year 1-3)

Dissemination will involve (1) progress briefings to stakeholders in Canberra in all years, (2) a user-friendly report describing the forecasting tool, and presenting the results of the use of the forecasting tool for Southeast Asia and the South Pacific written for a non-technical audience, (3) a dashboard tool which will allow analysts to input different parameters and will, using the underlying model, generate conflict predictions; (4) briefing and demonstration of the dashboard tool to the Government, and (5) a training workshop for Government practitioners in how to use the tool to conduct their own intelligence assessments, and forecast conflicts related to agricultural shocks. We will also conduct two outreach and collaboration workshops at the University of Sydney to train PhD students in the methods and approaches, to disseminate the results to interested organisations, and to build research capacity in Australia through the beginnings of a network of conflict researchers.

**Benefit**

The project will build on the models used in previous work, and synthesize findings from climate science, agricultural economics, and conflict studies in political science. The analytical framework will use multiple causal mechanisms, including output shocks, income shocks, and supply chain disruptions, to create a robust set of pathways connecting agricultural shocks to conflict. Through careful econometric analysis of the increasingly dense data on conflict incidents, specifically in relation to war-related trade blockages, climate variation, crop harvesting season, and price shocks, that can vary from year to year and across locations, we can forecast the location, timing, and type of civil unrest, insurgent or terrorist conflict, or even interstate conflict. Furthermore, to the benefit of the Australian intelligence community, we use proof-of-concept case studies for countries that are often ignored in the literature on climate and conflict, but are of strategic interest to Australia, namely Southeast Asia and the South Pacific.

This project squarely addresses National Intelligence Challenge 8 – “Situation awareness and multi-source assessment challenges.” Through its investigation of the causal pathways between agricultural shocks and conflict, the project shows how political, strategic, and economic factors can influence the location, timing, intensity, and type of conflict in strategically important areas. The model also directly incorporates measurable, tractable indicators of climate events and agricultural shocks from multiple open sources into the causal mechanisms leading to conflict, allowing analysts to determine the immediate security implications of environmental change.

While policymakers have no control over extreme weather and have very little control over the world prices of key staples, they have levers to mitigate some of the consequences of these shocks. By quantifying and elucidating the links between agricultural markets and conflict, this research will create innovative mechanisms that will allow policy makers to optimize their decision making by (1) directing their resources when and where they are needed the most to avoid any conflict that directly impacts the livelihoods of people and can be costly, particularly if escalated to larger scale events; (2) mitigating agricultural shock and conflict-related supply chain and security issues likely to be faced by deployed Australian Government assets; (3) forecasting where and how conflicts are likely to lead to food insecurity, and knock-on conflicts, particularly in areas of strategic interest to Australia.

**INVESTIGATORS/CAPABILITY**

The project team’s capabilities are designed to bring theoretical, area studies, and methodological expertise to bear to bring the project to a successful conclusion. As an expert in agricultural economics and non-linear time series econometrics, CI Ubilava has extensively studied regime dependencies in international commodity price behavior, and price co-integration within commodity groups. He will be particularly involved in econometric analysis of time series data.

As an expert in East Asia and the Indian Ocean Region, weak and failed states, non-state actors, and informal markets, CI Hastings has researched and published extensively on fragile and failed countries, including in Indonesia and the Philippines (among others). Hastings will be particularly involved in providing substantive knowledge of regional politics, understanding of conflict dynamics, and in developing the causal pathways between agricultural shocks and conflict. Hastings also has extensive experience in dealing with governments, and briefing and training practitioners and analysts in his research, and the frameworks he has developed.

Starting his career in 2001 as an analyst for Australian Defence, PI Hammond has a PhD in environmental economics and for the past ten years has worked for the Institute for Economics and Peace (IEP), a not-for-profit Australian based think tank conducting quantitative research on peace and conflict globally. IEP is best known for its annual reports the Global Peace Index and the Global Terrorism Index, which compares 163 countries on the levels of violent conflict of varying forms. Since 2020, IEP has also published it Ecological Threat Report (ETR) which looks at the intersection of resources scarcity and violent conflict. Hammond has extensive experience working with governments, Civil Service Organisations, and the major multi-laterals such as the United Nations and the World Bank. In his time at IEP, Hammond has overseen the production of a large database on resources scarcity, economics, politics and conflict, with granularity at the national, administrative unit, municipalities and city levels. Hammond has written and overseen all of IEP’s major reports, and published its research in academic journals.

A PhD student with an interest in forecasting models, econometrics, and conflict or agricultural economics will be part of the team, will be trained by CI Hastings and CI Ubilava, thus building research capacity, and will assist the team in conducting the research and in preparing and analysing the data.

A PhD-level Research Assistant with knowledge of econometrics, computer programming, and conflict studies will assist with data collection, preparation, and visualization and dashboard tool development, as well as the dissemination products and training outreach workshops. Both the PhD student and the Research Assistant will contribute to the research outputs.

All members of the team will be involved in writing up the results for publication. The CIs and PI are well-known and respected on the international level and have a proven capability to build collaborations both within Australia and internationally. The CIs and PI work with international co-authors across the globe, which has resulted in high-quality widely-cited publications. They regularly present at international conferences and serve as reviewers in top international journals.

**FEASIBILITY AND COMMITMENT**

The project is designed to be resilient to potential disruptions that could threaten completion of the project. Conflict and agriculture are both topic areas that are rich in data, and the main challenge is not to collect new data so much as to determine which data sources are relevant in forecasting conflict and food insecurity. The CIs are well placed to take advantage of available data, and have expertise in working with agriculture and conflict data, and building models to explain conflict patterns associated with agricultural shocks. Feasibility of the project will be particularly assured because we will use open source data, which eases data collection and preparation. The models to be developed are straightforward to build and test, inasmuch as they are based on the CIs’ previous models based on conflict seasonality, and linking conflict and market integration (Hastings et al 2022). As IEP collects most of this data on a regular basis as part of their core operations, risks associated with data collection risks (i.e. data found to be not available, lack of understanding of the nuance of the data, unsustainable data management process, etc) to this project are minimal. Management of the project will be based on close collaboration between the team members, who have previously collaborated on grants and resulting publications.

**Implementation plan**

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| --- | --- | --- | --- |
|  | **Year 1** | **Year 2** | **Year 3** |
| Research | - Agricultural shock-conflict model development  - Variable specifications  - Data collection, preparation | - Dashboard tool development  - Application of tool to regions of strategic interest | - Write-up |
| Publication and dissemination | - Submit article #1 (Framework)  - Conference presentations  - ONI conference/briefing in Canberra | - Submit articles #2 (Southeast Asia) and #3 (South Pacific)  - Conference presentations  - Outreach and collaboration workshop (Sydney)  - Briefing to Government (Canberra) | - Conference presentations  - Report distribution  - Tool demonstration  - Outreach and collaboration workshop (Sydney)  - Training workshop (Canberra) |

**COMMUNICATION OF RESULTS**

We will disseminate the results of the project in order to maximize uptake by different stakeholder communities.

1. For academics and interested audiences, we will publish **at least three articles** (one on the framework itself, one on Southeast Asia and one on the South Pacific)in leading, high-impact political science, economics, and development journals such as *World Development*, *Food Policy*, *American Journal of Agricultural Economics, International Studies Quarterly*, and *Political Geography*. All have previously published our work. We will also organise two **outreach and collaboration workshops** to train PhD students and other researchers in the early warning model, and the methods, and to begin to build a network of researchers in Australia interested in agricultural shocks and conflict prediction.
2. For the Australian government, in addition to **briefing** relevant stakeholders on interim results, we will produce a **user-friendly** **and non-technical report** describing the tool, and showing the results based on past data for Southeast Asia and the South Pacific, as well as discussing the conditions in which conflict is likely to take place in those regions. We will further deliver and demonstrate the **early warning tool**, and provide a **training** **workshop** for Australian intelligence analysts in its use with out-of-sample data.

**REFERENCES**

Adams, C., Ide, T., Barnett, J. and Detges, A. (2018) Sampling bias in climate–conflict research. Nature Climate Change, 8 (3), 200-203.

Bazzi, S. and C. Blattman (2014). Economic Shocks and Conflict: Evidence from Commodity Prices. *American Economic Journal: Macroeconomics 6*(4), 1–38.

Bellemare, M. F. (2015). Rising Food Prices, Food Price Volatility, and Social Unrest. *American* *Journal of Agricultural Economics 97*(1), 1–21.

Berman, N. and M. Couttenier (2015). External Shocks, Internal Shots: The Geography of Civil Conflicts. *The Review of Economics and Statistics 97*(4), 758–776.

Berman, N., M. Couttenier, D. Rohner, and M. Thoenig (2017). This Mine is Mine! How Minerals Fuel Conflicts in Africa. *American Economic Review 107*(6), 1564–1610.

Blair, G., D. Christensen, and A. Rudkin (2021). Do Commodity Price Shocks Cause Armed Conflict? A Meta-Analysis of Natural Experiments. *American Political Science Review*, 1–8.

Brückner, M. and A. Ciccone (2010). International Commodity Prices, Growth and the Outbreak of Civil War in Sub-Saharan Africa. *Economic Journal 120*(544), 519–534.

Buhaug, H., T. A. Benjaminsen, E. Sjaastad, and O. M. Theisen (2015). Climate Variability, Food Production Shocks, and Violent Conflict in Sub-Saharan Africa. *Environmental Research Letters 10*(12), 125015.

Choi, H. J., & Raleigh, C. (2021). The Geography of Regime Support and Political Violence. *Democratization*, 1-20.

Collier, P. and A. Hoeffler (1998). On Economic Causes of Civil War. *Oxford Economic Papers 50*(4), 563–573.

Crost, B. and J. H. Felter (2020). Export Crops and Civil Conflict. *Journal of the European Economic Association 18*, 1484–1520.

Dube, O. and J. F. Vargas (2013). Commodity Price Shocks and Civil Conflict: Evidence from Colombia. *Review of Economic Studies 80*(4), 1384–1421.

Fjelde, H. (2015). Farming or Fighting? Agricultural Price Shocks and Civil War in Africa. *World Development 67*, 525–534.

Harari, M. and E. L. Ferrara (2018). Conflict, Climate, and Cells: A Disaggregated Analysis. *The Review of Economics and Statistics 100*(4), 594–608.

Hastings, J. V., Phillips, S. G., Ubilava, D., and A. Vasnev (2022) Price Transmission in Conflict-Affected States: Evidence from Cereal Markets of Somalia. *Journal of African Economies (in press)*.

Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thépaut, J-N. (2018): ERA5 Hourly Data on Single Levels from 1979 to Present. *Copernicus Climate Change Service (C3S) Climate Data Store (CDS)*.

Institute for Economics & Peace. Global Peace Index 2022: Measuring Peace in a Complex World, Sydney, June 2022.

Institute for Economics & Peace. Positive Peace Report 2022: Analysing the factors that build, predict and sustain peace, Sydney, January 2022.

Institute for Economics & Peace. Ecological Threat Report 2022: Analysing Ecological Threats, Resilience & Peace, Sydney, October 2022.

Iizumi T, Sakai T. The global dataset of historical yields for major crops 1981-2016. Sci Data. 2020 Mar 20;7(1):97.

Koren, O. (2018). Food Abundance and Violent Conflict in Africa. *American Journal of Agricultural Economics 100*(4), 981–1006.

Koren, O. and B. E. Bagozzi (2017). Living Off the Land: The Connection Between Cropland, Food Security, and Violence Against Civilians. *Journal of Peace Research 54*(3), 351–364.

Maystadt, J.-F. and O. Ecker (2014). Extreme Weather and Civil War: Does Drought Fuel Conflict in Somalia Through Livestock Price Shocks? *American Journal of Agricultural Economics 96*(4), 1157–1182.

McGuirk, E. and M. Burke (2020). The Economics Origins of Conflict in Africa. *Journal of Political Economy 128*, 3940–3997.

Miguel, E., S. Satyanath, and E. Sergenti (2004). Economic Shocks and Civil Conflict: An Instrumental Variables Approach. *Journal of Political Economy 112*(4), 725–753.

Mizik, T., Szerletics, A., and Jambor, A., 2020. Agri-Food Export Competitive of the ASEAN Countries*, Sustainability*, 12(23), 1-15.

Monfreda, C., Ramankutty, N., & Foley, J. A. (2008). Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000. *Global biogeochemical cycles*, *22*(1).

Raleigh, C., A. Linke, H. Hegre, and J. Karlsen (2010). Introducing ACLED: An Armed Conflict Location and Event Dataset: Special Data Feature. *Journal of Peace Research 47*(5), 651–660.

Raleigh, C. (2012). Violence Against Civilians: A Disaggregated Analysis. *International Interactions, 38*(4), 462-481.

Raleigh, C. (2014). Political Hierarchies and Landscapes of Conflict Across Africa. *Political Geography, 42*, 92-103.

Raleigh, C., Choi, H. J., & Kniveton, D. (2015). The Devil Is In the Details: An Investigation of the Relationships Between Conflict, Food Price and Climate Across Africa. *Global Environmental Change, 32*, 187-199.

Raleigh, C., & Kishi, R. (2020). Hired Guns: Using Pro-Government Militias for Political Competition. *Terrorism and Political Violence, 32*(3), 582-603.

Sacks, W. J., D. Deryng, J. A. Foley, and N. Ramankutty (2010). Crop Planting Dates: An Analysis of Global Patterns. *Global Ecology and Biogeography 19*(5), 607–620.

Smith, T. G. (2014). Feeding Unrest: Disentangling the Causal Relationship between Food Price Shocks and Sociopolitical Conflict in Urban Africa. *Journal of Peace Research 51*(6), 679–695

Vestby, J. (2019). Climate Variability and Individual Motivations for Participating in Political Violence. *Global Environmental Change, 56*, 114-123.

von Uexkull, N., & Buhaug, H. (2021). Security Implications of Climate Change: A Decade of Scientific Progress. *Journal of Peace Research, 58*(1), 3-17.

Wischnath, G., & Buhaug, H. (2014). Rice or Riots: On Food Production and Conflict Severity Across India. *Political Geography, 43*, 6-15.