April 2022

NYU CIC | CENTER ON INTERNATIONAL COOPERATION

DATA FOR PEACEBUILDING AND PREVENTION

Can Emerging Technologies Lead a Revival of Conflict Early Warning/Early Action? Lessons from the Field

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About The Center on International Cooperation

The Center on International Cooperation (CIC) is a non-profit research center housed at New York University. Our vision is to advance effective multilateral action to prevent crises and build peace, justice, and inclusion. Our mission is to strengthen cooperative approaches among national governments, international organizations, and the wider policy community to advance peace, justice, and inclusion.

Acknowledgments

The NYU Center on International Cooperation is grateful for the support of the Netherlands Ministry of Foreign Affairs for the production of this report. We also offer a special thanks to all session organizers and speakers who provided the webinar content and contributed with comments to the final edition of this report.

This report should be cited as: Panic, Branka, "Can Emerging Technologies Lead a Revival of Conflict Early Warning/Early Action? Lessons from the Field" (New York: NYU Center on International Cooperation, 2022).

Table of Contents

Introduction

"We noticed that quite a few governments and multilaterals were developing their own early warning capacities and also investing in local and national capabilities on early warning/early action. At the same time, there has been an acceleration in the volume and speed of information available, as well as a proliferation of methods to detect patterns and analyze this information. We felt strongly that there was a need for a space in which people could just get to know the approaches that have been taking shape, with the aims of building on one another's insights on early warning and exchanging on models for early action, instead of duplicating efforts."

— **Paige Arthur**
NYU Center on International Cooperation
Deputy Director

The early warning/early action (EWEA) community has been working for decades on analytics to help prevent conflict. The field has evolved significantly since its inception in the 1970s and 80s. The systems have served with variable success to predict conflict trends, alert communities to risk, inform decision makers, provide inputs to action strategies, and initiate a response to violent conflict. Present systems must now address the increasingly complex and protracted nature of conflicts in which factors previously considered peripheral have become core elements in conflict dynamics.

"The Government of the Netherlands made Early Warning/Early Action a central part of our planning in the security policy process. It is already one of the pillars of our Integrated Security Strategy and we think this is important because we believe prevention is key to prevent human suffering and conflict and the way we are able to use and leverage technology is extremely important."

— **Wouter Jurgens**
Dutch Ministry of Foreign Affairs
Deputy Director, Security Policy Department

As our global and local environments become more interconnected, with junctions of multiple and cascading risks, being able to track these risks and anticipate their consequences is exceeding human capabilities. At the same time, advances made in quantitative and qualitative analytical tools, machine learning (ML), and artificial intelligence (AI) are providing us with new tools to tackle this analytical work. These same tools could support a revival of the EWEA field along with its effectiveness for prevention and peace-building work.

This report starts by surveying the data-driven techniques with the greatest potential to revolutionize the field, along with emerging trends in data and modeling. We then review contextual thematic issues most likely to shape EWEA (such as the COVID-19 pandemic and climate change), and conclude with recommendations for engaging emerging technologies in EWEA's future development.

Bringing 1,000+ EWEA Practitioners Together

The Early Warning/Early Action (EWEA) Practitioners Workshop was organized as a three-day virtual gathering over May 18-20, 2021. The workshop provided a platform for more than thirty-five session organizers, over a hundred experts, 318 organizations, and 1,000-plus participants from 90 countries, exploring cutting-edge approaches in utilizing data and technology to predict and prevent conflict and sustain peace. With the changing nature of conflict and the emergence of new challenges, we wanted to see how different stakeholders in this field cope with those challenges, along with how emerging technologies are seen and used as a helpful tool in this work.

The workshop's overall objective was to:

- **Facilitate peer-to-peer exchange on best practices in EWEA**
- **Contribute to rethinking the current stage of EWEA systems**
- **Discuss the future direction of their development**

More details about the workshop's goals and how to move forward can be found at the workshop's opening and closing panels:

- The Present and the Future of Early Warning/Early Action[1]
- New Threats and New Tools – Moving Forward[2]

The event marked the first time that national and international actors, civil society, international organizations, private sector, and government representatives were brought together at the international level to share lessons learned on effective EWEA models, practices, methods to influence decision making, and conflict prevention on the ground.

> *"We are on the cusp of a revolution in early warning capabilities. This combination of massive data availability, increased processing and computational power, and new methods is game changing—we're able to do more complex modeling and simulations in ways that we never really imagined possible."*
>
> — **Robert Muggah**
> **Igarapé Institute and SecDev Group**
> Co-Founder

Geospatial Information Technologies

Applications of geospatial technologies (e.g., geographic information science [GIS]), remote sensing, and satellite navigation systems (like GPS) are producing new approaches to conflict-related EWEA. With hundreds of satellites circling the earth, the insights from data they provide can be invaluable for the work of peace-building and prevention practitioners, especially in situations of restricted access such as conflict zones. By deploying special data and modeling tools, experts can analyze risks, identify where people are most vulnerable, and support risk-informed policies.

Once conflict breaks out, one of the easiest ways to see if there has been violence is through **damage assessment of buildings** via analysis of satellite images. A recent example is the in-depth analysis of satellite imagery after hundreds of Rohingya villages in northern Rakhine State were burned to the ground, forcing hundreds of thousands of Rohingya to leave their homes.[3] This analysis helped activists and experts to shed light on the reshaping of the region. Similarly, Space4Good, in cooperation with the Carter Center, has explored verifying, assessing, and monitoring the consequences of the Syrian military conflict with regard to **explosive weapons contamination** in several districts.[4] **Population displacements**, also visible through satellite images, can be an early indicator of the beginning of a conflict and can also be used to plan humanitarian assistance and help affected populations. **Fire detection** is another area where satellites are better than humans. Alongside media reports, visual representation through satellite imagery helps to realize the scale and severity of attacks causing a fire. Fire-related deforestation can serve as an early warning, as it often

leads to environmental degradation and economic insecurity—and consequently to conflicts. **Natural resources** represent another important area where satellite images can be beneficial tools: resource exploitation can be a contributing factor in upcoming conflicts.

Although the work with satellite imagery is not new, the last five to ten years has seen an increased number of satellites and with them, greater **availability of images**. The **"cloud"** is also changing how this work is being done, with Google Earth Engine, Copernicus Data Hub, and similar sources enabling much quicker analysis. **Observation platforms**, such as Planet, providing daily imagery at a lower resolution, or HawkEye360, providing mapping of radio transmissions at certain frequencies, are other new resources for researchers. Additionally, **open GIS software** is available, along with a number of courses and a rich user community offering knowledge on multiple forums for those eager to harness the potentials of GIS and satellite imagery in their EWEA work.

Artificial Intelligence advances can help address some of these issues at scale, automating analysis that was previously possible only with limited staff time and capabilities. The task of detection is, however, highly complex, and machine learning models still have a way to go to correctly identify war-related destruction. Progress has been made over the last two years at Universitat Autònoma de Barcelona (UAB), the Institute of Economic Analysis at the Spanish National Research Council, and Chapman University, California, where researchers have trained models to detect the impact of heavy artillery in urban spaces.[5] However, as Paige Arthur notes, outside of a specific geographical zone of interest or reports from trusted

> *"The advancement in (satellite) technology can help us detect more changes—and to understand the changes and validate what they are."*
>
> — Elham Goumehei
> Space4Good
> Radar Remote Sensing and Machine Learning Scientist

sources on the ground, these models still "really don't know where the destruction is, or where the human rights abuses have taken place."[6]

Ultimately, many actors in the conflict EWEA field are still behind in terms of the absolute cutting-edge approaches in GIS and satellite imagery. These tools are still in the hands of Google, Digital Globe, Maxar, and other big companies, with a military focus or developed for government purposes.

Machine Learning (ML) and Natural Language Processing (NLP)

An increasingly relevant tool is the utilization of text analysis, including online news and social media posts, in tandem with machine learning techniques, such as natural language

processing, for gathering and processing data and conflict modeling. This advanced technique can change unstructured data (e.g., language) into structured data, such as various types of sentiment scores.

The European Commission Disaster Risk Management Knowledge Centre (DRMKC) is testing a novel conflict event modeling framework employing data from the Europe Media Monitor (EMM). This work, part of the Global Conflict Risk Index (GCRI), ranks 191 countries and measures the intensity and the probability of conflict at a country level in the next one to four years. Drawing on a class of NLP techniques, the GCRI uses the Conflict and Mediation Event Observations (CAMEO) codebook to track conflict events from textual data flowing out of the large-scale EMM news aggregation engine that gathers articles from approximately 7,000 sources in 60 languages on a 24/7 basis. A comparison of the differences between the CAMEO codebook and the EMM taxonomy led to the formulation of a new and expanded codebook with wider coverage of conflict events and more fine-grained event representation.[7]

Conflictforecast.org is another example that provides a new set of quantitative benchmarks for conflict prevention. The system provides open access to eight monthly forecasts for outbreaks of armed violence up to a year before they occur. All forecasts are based on a database of more than five million continuously updated newspaper articles, from sources including *The New York Times*, *The Economist*, BBC Monitor, Associated Press, and LatinNews. This model aggregates timely, expert information and combines unsupervised and supervised ML to train the model for early warning signals.[8]

The potential for ML applications, of course, goes beyond language processing. Another use is to provide fresh analysis of traditionally gathered risk scores. Virtual Research Associates presented promising results from using ECOWARN risk scores to forecast and warn of the escalation of conflict and associated outcomes such as human deaths and injuries. This approach combines econometrics and ML with weekly data from field "situation reports" over the period 2012–2020 for the 15 ECOWAS member states. While econometrics proved useful in providing an overview of the correlation and for historical analysis, ML enabled processing five million data points within thirty minutes, demonstrating its power to analyze ever-larger datasets.[9]

These technologies are also being deployed for humanitarian purposes in Syria. Hala Systems has developed a platform that constantly monitors posts from social media, like Facebook, Twitter, and Telegram, flagging those that mention airstrikes in Syria, and then correlating these reports with observed aircraft activity. This information helps train their ML algorithm so that the system can provide more accurate warnings of future airstrikes. Originally this process was performed by human experts, who spent a significant amount of time searching social media for relevant information about airstrikes. This was an emotionally heavy and time-consuming process, and the huge volume of data hampered the monitors' ability to cover everything. Now the system is able to cover different types of incidents in different languages using recent advances in NLP, such as multilingual deep learning methods. The system is trained to decide which incidents are relevant, and to extract relevant features such as time and location.[10]

ML applications have also been developed in cutting-edge approaches to documentation and investigation of massive human rights abuses and violations of humanitarian law. For

example, Mnemonic helps human rights defenders to use digital documentation of human rights violations and international crimes. Working with more than three million records only in Syria, this team has harnessed the power of ML to support legal case building or advocacy efforts.

There are some emerging exploratory areas to deepen this kind of work. For example, **computer vision and object detection**, as a subset of ML, are utilized in detecting a specific type of munition used—for example, cluster munitions, which are banned under international treaties. Object detection requires a considerable number of training examples, and in this case, the videos available make up barely 1 percent of what is needed for an AI to be trained. This is where **synthetic data** is used to unlock the potential of computer vision. Some of the latest cutting-edge research uses **3D printing** and **3D rendering** to generate image training datasets, enhancing algorithms for detecting illegal cluster munitions. This combination of computer vision, synthetic data, and 3D printing can assist human rights defenders and help expose war crimes in conflict areas.[11]

There are still significant limitations in utilizing NLP approaches, particularly in news event datasets. Some examples are duplication, misclassification, irrelevant articles, and unreliable sources. One of the most common challenges is the problem of classifying "fake news," typically tackled by relying on the authenticity of data sources (for example, the use of vetted Twitter account of a journalist, or trusted Telegram channels). There is also a need to address multilingual issues (where events are being reported in many different languages) and the lack of annotated data in these languages. ML can provide identifiable benefits in multimedia event extraction by combining text and image information. This, however, adds to the challenge of annotation, as audio, image, and video can be useful only if annotated properly. Another recognized opportunity is increased access to local news sources, which can be used to advance conflict predictions at a subnational level. NLP, overall, provides an opportunity to develop more robust conflict event analysis systems, providing supplementary data inputs for existing early warning statistical prediction models or for developing new models.

Data Visualization

Conflict and related violence are characterized by a high degree of complexity and a rapid rate of change. This makes them exceedingly difficult to follow, understand, and analyze. Using quantitative data to track and map incidents of conflict and violence in real time can help identify trends and inform policy makers and the public. Effective data visualization is critical, as it can help stakeholders understand and analyze a crisis or a certain context quickly and from different angles. A carefully crafted visualization can reveal patterns not visible to human analysis, and also spur policy makers to act in a timely way.

There are many good examples of effective data visualization for early warning and action. What follows are just a few, drawn from a range of actors (governmental, intergovernmental, and private sector). The UN Development Programme's Crisis Risk Dashboard (CRD) relies heavily on graphics and visualizations to tell how the security situation is evolving and to inform its programming in countries like Cote d'Ivoire, Tunisia, Sri Lanka, and others. CRD is especially interesting as a tool that is available at global, regional, and country-specific

levels. As such, it provides important input on identifying the specific regions most prone to conflicts or violence and thus in greatest need of future program interventions. One UNDP CRD example developed for Sri Lanka is a visual representation of data manually identified and collected by the UN pinpointing online hate speech in social media. Hate speech propagated online can translate to hate crimes or citizen violence on the ground, and this type of visualization can be of great value in analyzing the context, receiving early warning signals, and preparing programing accordingly.[12]

Similarly, the UN peacekeeping mission in Mali (MINUSMA), in cooperation with the UN Operations and Crisis Centre (UNOCC), has developed an Early Warning Rapid Response mobile app for collecting early warning information submitted by authorized personnel through SMS or a phone call. The collected info immediately triggers automatic emails requesting responses from authorized personnel. Responses are also recorded through the app, providing more transparency and accountability. This tool brings together previously siloed information in a coherent and timely manner. It also provides data analytics and visualization of all data collected, while tracking response and enabling insight on what worked well in the process.[13]

An example from the private sector is Data42, a visual data analytics platform that allows those without data science skills to analyze data quickly and discover crises faster.[14]

Finally, the German Federal Foreign Office's PREVIEW section developed the "Delta-Analysis as a Pilot Study for Lake Chad Region" for operational data integration and early action planning and implementation. An important feature of the Delta Analysis is that it functions as an interactive visualization tool, allowing users to interact with multilayered data behind the tool. It gathers data from different ministries and practitioners in the field across the triple nexus, and also creates and visualizes both integrated views of operational presence and conflict prediction models.[15]

More data-driven challenges have been identified in the data visualization field, including lack of data skills and data literacy. The good news is that existing resources, including some from the private sector, can help bridge these gaps. For example, the well-known visualization software, Tableau, has created a foundation to help organizations in the public sector use their product more effectively. The foundation offers a variety of open source and publicly available tools in a bid to assist those with access to fewer resources in the advancement of their work with data visualization tools.[16]

Low-tech solutions also enable early warning and save lives

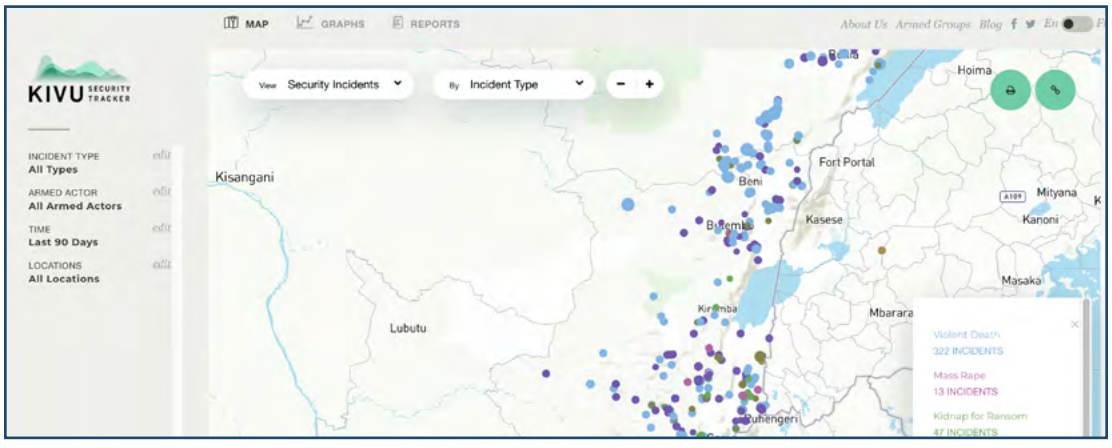
The work of many organizations on the ground shows that **low-tech solutions** can have equally high impact in predicting conflict and saving lives. Moreover, they can be more suitable solutions for some local contexts. Also, in a conflict context, access to new technologies or the internet is often limited. On the one hand, this can be an obstacle in utilizing the potential of new tools and increases the risk of "leaving people behind." However, it also opens the possibility of utilizing different lower-tech solutions, such as radio or TV.

Indeed, local early warning systems are often low-tech in their approach: in many remote regions, communities do not have access to the internet or mobile phones, which is why low-

> *"All who were alerted (via the EWS) are alive today."*
>
> — Farmer from Rafai
> Central African Republic

tech solutions are a more relevant approach to early warning and early action. For example, the Invisible Children early warning system in the Central African Republic connects over 150 communities to each other and the outside world through a system of high-frequency **HF radios** installed in isolated communities. Once the radios are installed, the community selects a peace committee trained to collect information related to protection, security, and rumor management. Participatory community mapping is used as an additional tool for identifying community "dividers" and "connectors," and understanding threats to the community. Communities participate in daily calls to share information horizontally, enabling other at-risk communities to implement risk mitigation strategies, as well as vertically with the Crisis Tracker team that alerts key stakeholders. Emails and WhatsApp alerts record incident-based reports and send them to a centralized **Crisis Tracker, a geospatial database and online mapping platform**. The database allows for the identification of trends in risks to civilians over time, enabling analysis which can be fed back into the EWS to alert communities to potential threats. These insights are being used to design upstream prevention through distribution of **SD memory cards** spreading peace messages. The information also aids with immediate prevention, such as **HF radio alerts to warn communities** about armed group movements.[17]

Another example is The Kivu Security Tracker, a joint project of the Congo Research Group and Human Rights Watch. Using a system of monitors and SMS technology, it maps near-real-time violence committed by state security forces and armed groups in eastern Democratic Republic of Congo to better understand trends relating to the causes of insecurity and serious violations of international human rights and humanitarian law.[18]



Screenshot from Kivu Security Tracker, March 2022, retrieved from https://kivusecurity.org/map.

Lack of data—or good quality data—is a common challenge, in addition to the need for models adapted to the high degree of complexity and dynamism inherent to conflicts. New data sources and new methods for data analysis are therefore a key element of reshaping early warning and action approaches.

New data sources - social media and other online data resources

Social media data and monitoring is a relevant complement to data used in traditional conflict EWEA or conflict modeling. There are many tools to conduct analysis on public content on Facebook and Twitter. For example, CrowdTangle is a public insights tool that makes it easy to follow, analyze, and report on what is happening with public content on social media, including Facebook, Instagram, and Reddit.[19] Third party actors like CITRIS and the Banatao Institute at University of California, Berkeley have also offered hands-on guidance on how to analyze Twitter.[20] They describe how Twitter has made its data available via special permit, creating an application programming interface (API) that allows users to pull tweets and other data from Twitter's servers for research purposes.

Organizations are now working to integrate some of these tools into their early warning systems by utilizing online signals from social media data as early warning indicators. While the problem of false and misleading information was marked by many as an obstacle in the work of modeling (i.e., entering false information in prediction models and decision-making systems), some also saw this as an opportunity: **misinformation** and **hate speech** could be indicators of violence informing early prevention efforts. For example, UNDP Sri Lanka monitors hate speech and how it translates to violence and conflict on the ground. Another example, Hatebase, is a multilingual database of online hate speech that serves as a large lexicon of hate speech keywords in various languages.

Data collection through local partnerships

More data sources do not necessarily lead to more reliable data. Actors across different sectors are facing similar challenges in data quality, resolution, and coverage. There is a risk of reproducing existing biases through already biased resources. There are several innovative approaches to tackling some of these challenges.

One approach taken by the Armed Conflict Location and Event Data Project (ACLED) has been to prioritize local reporting in local languages, as opposed to, for example, international US-based media outlets which report only certain types of events. ACLED is partnering with local conflict observatories such as Cabo Ligado in Mozambique, Yemen Data Project, Militia

Watch in the US, and Afghan Peace Watch. Responding to a lack of data about the insurgency in Cabo Delgado province, and filling the gap in reporting about the region, ACLED established Cabo Ligado in partnership with local media groups as a resource for information based on online sources and correspondents in the province.[21]

ACLED is a key source of general data for many prediction models and decision making, but some are taking steps to incorporate input from local nonprofits producing data in a disaggregated and more regular form (such as UNDP and the UN resident coordinator's office in Tunisia). This cooperation goes in the other direction as well: ACLED uses data from Kivu Security Tracker (mentioned above) and the data collected from seventeen focal points across three provinces in the Congo to inform their data.

Peloria Insights has also found value in combining a collection of online data and cutting-edge big data processing with traditional surveys and ground-level research, resolving data gaps in regional or gender representation. Peloria employs multidisciplinary social science knowledge to inform AI that predicts social unrest, violence, and related economic disruption.[22]

ECOWAS's early warning process is based on local data gathered through seventy-seven field monitors in fifteen ECOWAS Member States. All have a mandate to collect data and report to ECOWARN any incident that has a potential impact on human security, and fill out a weekly questionnaire comprising fifty-five indicators. Through this approach, the system is decentralizing EWEA to the national level, achieving more expedient implementation and bridging the gap between early warning and early response. Incidents are reported in real time in the ECOWARN web database, enabling situational analysis via thematic-based indicators.[23]

Dealing with the challenge of misinformation and disinformation

In an age of misinformation and disinformation affecting all spheres of our lives, it is only natural to expect this topic to be an issue for the EWEA field as well. In the case of field monitors who serve as data and signal collectors, this challenge is addressed by introducing an additional layer of verification before the data is used for analysis and rapid response. In the Ethiopian Conflict Early Warning and Rapid Response system (CEWRR), information submitted by local monitors is first evaluated by administrative structures. On the other side, information captured by mainstream and social media is not acted upon until it is tagged, meaning the local structures must verify whether the information is true or false.[24]

The Congo Research Group shared their experience in dealing with unverified reports that inform their Kivu Security Tracker. With the increased availability of WhatsApp and smart phones, the team receives a large quantity of reports. These bring the risk that some of the information has been manipulated and is in need of verification. To tackle this problem, the project turned to recruiting researchers, journalists, and civil society activists to serve as focal points located in the areas where violence is happening. These entities are responsible for personally verifying the data.

It is worth noting that dealing with misinformation and disinformation in the EWEA field is labor intensive and relies on human interpreters. So far, we have found no models that use automated methods to screen out some of the bad information in order to lighten the workload of human reviewers. This is an area for potential future growth.

From short- to long-term and from national to subnational modeling

Contemporary EWEA systems take quite different approaches depending on the specific context, objectives, and needs. One key example is strategic versus tactical early warning, including different prediction timeframes **from shorter to longer prediction horizons**. The European External Action Service and its early warning system aim to change longer-term conflict dynamics by predicting a conflict in one to four years' time. On the other hand, **horizon scanning** looks three to six months ahead to deal with the crisis more immediately, rather than attempting to transform a conflict dynamic. Indeed, much of the continued interest in EWEA stems from the potential for data-driven solutions to enable **more anticipatory planning across different time periods.**

One of the best-known approaches to forecasting political violence, ViEWS by the Department of Peace and Conflict Research at Uppsala University, has gathered its lessons learned over the previous five years. They conclude that different models are required when forecasting three months into the future, versus three years. ViEWS has also demonstrated the so-called "wisdom of the crowd," in which multiple models together perform better than single models. To overcome the problem of lack of data (armed conflicts are rare events), ViEWS trains its models on one part of the data and evaluates performance on another. For example, it trains data up to 2017, sets aside 2018–2020, and then evaluates models for a given "step ahead" against all months 2018–2020.

Another approach comes from the Department of Political Science, University College London, which uses an **actor-centric approach rather than a geographic approach to forecasting**. This model predicts the actions of specific actors, such as the government or a rebel organization, as opposed to what might happen in a particular geographic space. There are three main arguments for choosing this approach:

1. the data-generating process is on the actor level (meaning it is actors who are making decisions whether to fight, not a geographic unit)
2. strategic dynamics are on the actor level rather than geographic level
3. there are clearer implications for peace processes[25]

A recent trend is moving from only global, country-level, and national modeling toward more **subnational, regional, local, and sublocal predictions** with a higher spatial resolution. Another approach becoming more common is "**ensembling**": instead of relying on one single model, forecasters can "ensemble" multiple models to account for variances. VFrame explains this through their work on videos they collect to document war crimes in Yemen and Syria: video taken on a high-resolution digital camera may contain so much texture that it will not be detected by a network trained on low-resolution images. The solution is to ensemble the models, training each for every kind of specific cluster of sensor technology and chaining them all together so the model becomes an ensemble of smaller models.[26]

> *"[It's important] not only to have anticipatory action six months or few hours before something happens, but really to think about a longer timeframe—upstream and structural prevention."*
>
> — **Henk-Jan Brinkman**
> **United Nations Peacebuilding Support Office**
> Chief of Peacebuilding Strategy and Partnerships

COVID-19 pandemic and compound risks

The past several years have seen increasing recognition of the complexity and interconnectedness of a diverse set of risks. The **COVID-19 pandemic** revealed the need to look beyond unidimensional approaches to early warning and early action, and to address crises through a "compound" lens.

Recent examples of this trend include the *Global Crisis Risk Platform at the World Bank,* which is developing a methodology to **monitor compound risks** (and, alongside that, monitor conflict) to help better inform the decisions within the World Bank Group. Substantial effort has also been made within the UN both to move **from crisis response to participatory action** and to focus on the multidimensional character of risks.

Still, the idea of predicting extremely complex compounding risks remains largely beyond our grasp. At this stage of development, priorities may need to focus on identifying preconditions for compound crises, along with developing stronger capacities to analyze the connections between risks in the domains of natural hazards, macroeconomics, public health, conflict, food security, and socioeconomic vulnerability. At the moment, these six dimensions are

> *"We found out that about half of humanitarian needs are foreseeable and 20 percent are highly predictable. Yet only 1 percent of finances are prefinanced. We believe that anticipatory action is cheaper, faster, more dignified, and protects development gains."*
>
> — **Dirk-Jan Omtzigt**
> **UN OCHA**
> Chief Economist

rarely considered together. Within each field, we have good indicators for recognizing when risks have increased to a point where a country is no longer able to deal with them. The next level is to find different ways of combining these indicators to analyze when certain risks are having compounding effects, both nationally and subnationally.[27]

Climate change and climate security modeling

Environmental security and water-related risks have emerged as key thematic issues for EWEA, as climate change may be linked to new risks for competition, instability, and violent conflict—especially in contexts where there are environmental shocks or weak governance.[28] While capacity of many organizations and researchers to provide data-driven insights is growing, a fully quantitative and predictive EWEA system has not yet been achieved. There is therefore an urgent need to integrate analysis of environmental data and build capacity and skills for practitioners and policy makers to access and use this data.

There have been some promising efforts. The UN Environment Programme has developed STRATA, the Earth Stress Monitor, to rapidly identify climate and environmental hotspots, provide insights into where and when these will occur, and quantify overlap with structural socioeconomic risks that potentially drive displacement, social unrest, conflict, or maladaptation. Similarly, The Potsdam Institute for Climate Impact Research has its Weathering Risk Initiative, a global climate and security risk and foresight assessment, which addresses the lack of knowledge of when and how climate change affects the risks of conflict and human security. The initiative aims to support risk-informed planning and improve operational responses through deeper understanding of climate, sustainable development, security, and peace building as crosscutting issues. This work is looking at short, medium, and long-term risks posed to peace, prosperity, and wellbeing, and combines quantitative and qualitative assessments and foresight methods. Through supervised machine learning and regression analysis, this project aims to verify the contexts and pathways whereby climate change exacerbates risks of conflict.

The Fragility, Conflict, and Violence unit at the World Bank is creating a dataset that integrates environmental and conflict risks using machine learning techniques to measure conflict vulnerability, mapping areas where joint risks are highest, and demonstrating different profiles of vulnerability.[29] The Water, Peace, and Security (WPS) partnership aims to address the water conflict nexus by developing innovative tools, raising awareness, building capacities to respond to risks, and supporting dialogue in conflict-affected regions. WPS developed a machine learning-based tool that predicts conflict over twelve months using real-time climate data and weather-related variables.[30]

Forced displacement and conflict modeling

82.4 million people had been forcibly displaced worldwide at the end of 2020 as a result of persecution, conflict, violence, and human rights violations. There is an emerging effort to provide more insight into the dynamics of forced displacement over time and space in supporting humanitarian, development, and peace-keeping efforts in affected countries. Organizations including the Danish Refugee Council and Kimetrica have thus been exploring the combination of **forced displacement and conflict modeling**. Kimetrica, for example, has developed a predictive model forecasting the proportion and number of internally

displaced persons at the admin2 level (districts, counties, cercles, and communes) on a quarterly basis, advancing research from the national to subnational level.[31]

Protection of civilians, youth, and children affected by conflict

Since EWEA has not yet succeeded in making violent conflict a thing of the past, it remains essential to innovate new technologies for real-time situational awareness that can help people avoid threats and navigate dangerous situations.

Hala System's project Sentry is one well-respected example. This early warning system for airstrikes in Syria links a network of human observers and "internet of things" devices to detect, predict, and warn the public about potential airstrikes seven to nine minutes before the strike happens. Since its inception, this system has reduced casualties 20 to 30 percent, saved hundreds of lives, and prevented thousands of injuries, providing information to 2.3 million people.

Child protection is a critical area where emerging EWEA approaches might address a range of risks. For example, preventing the recruitment and use of children by armed groups would benefit from greater investment in evidence-based early warning systems that can identify such actions at early stages and funnel evidence to the right stakeholders for preventative action. One challenge is whether these systems need to be developed as a component of a broader conflict EWEA, or as specific child recruitment prevention models. Early Warning System in Colombia is an example of a strategy that includes indicators for monitoring, warning, and prevention of child recruitment and use by armed groups. Elman Peace in Somalia is another example of community-based prevention and child protection. Its approach recognizes the importance of clan elders, as well as women and mothers, who understand the local context, understand the communities, and are in a position to recognize which children are at highest risk for being recruited.

Additionally, the Dallaire Institute for Children, Peace and Security has piloted the Knowledge for Prevention (K4P) project which aims to shape early warning and action by providing timely alerts and strengthening collaboration to better protect children in conflict environments. The project has produced its first dataset on evidence of recruitment. It also developed a predictive model to raise awareness of the risks of recruitment at an early age. The model incorporates child-centered indicators within early warning systems monitoring conflict prevention.[32]

The Future of Conflict EWEA Data-Driven Approaches: Five Areas for Improvement

We live in a world where there is much more data than ever before. This data is essential for improving the effectiveness of EWEA tools—but it is not sufficient. Effective early warning and early action need a dynamic combination of technology, data, subject matter experts, and local knowledge. We also need to recognize that this field is interdisciplinary, connecting statisticians, data scientists, technologists, social scientists, designers, and more.

In short, we need a more robust ecosystem of "data for peace." The report NYU CIC published in October 2020 analyzes this ecosystem in detail and goes a step further by recommending the creation of a **hub for peace-building and prevention data**, as a place to gather not only data and models but also people and partnerships necessary for the future development of a data for peace ecosystem. The successful example of OCHA's Centre for Humanitarian Data is one inspiration for building the infrastructure that humanitarian actors needed to share data, models, standards, and resources. Over the past year, the UN has piloted its **Peace and Security Data Hub**, which consolidates data and information relating to the peace and security pillar at the UN.

With these points in mind, we observe five priority areas for action.

Bridge the gap between early warning and early action

One of the most frequent challenges for EWEA is the difficulty in ensuring that early warning information leads to a timely and effective response. Many EWEA systems have proven high accuracy in predicting the probability of conflict. However, that doesn't advise decision makers what to do—only what is going to happen if they do not do anything. There is a need to escape the "binary trap" (predicting the probability of conflict happening or not happening) and avoid oversimplifying an emerging conflict. We certainly need to know if and when a conflict is approaching—but we also need to understand its drivers, actors, and other nuances well enough to inform an effective response.

Several EWEA "pain points" have been identified. Some of these can benefit from emerging technologies, but others require political thinking and low-tech solutions. One key example of the latter is the ongoing need to build early action structures in a way that **ensures political buy-in** of relevant actors to support decision making. It can be difficult to convince decision makers to invest in long-term efforts, rather than just responding to an immediate crisis. There are several good models for this engagement, including the national coordination centers for early response in the ECOWAS countries. These centers sit in government, often in the prime minister's office, and are therefore uniquely positioned to access levers across ministries when their data shows that risks are beginning to rise. They also cultivate links with municipalities and local authorities, such as religious and traditional leaders.[33]

Other approaches to tackle the "pain points" and bridge the warning/action gap include:

- **Coordination and response alignment:** A variety of actors will need to share warnings quickly and provide more transparency in their response so that important information does not stay locked in silos. The UN Peacekeeping Mission in Mali tackled this challenge by creating an app that collects all warnings in real time, transparently, and documents all responses—avoiding the previous problem of not knowing which actor responded, when, and how. More transparency is also needed to ensure greater accountability.[34]
- **Data visualization:** Engaging visualizations that tell clear stories can help bridge the gap between people who have technical knowledge and political decision makers. Developed by the German Federal Foreign Office's PREVIEW-section, the Delta-Analysis is one such example that provides interactive front-end visualizations and an analytical framework to guide early action planning and implementation.[35]
- **Subnational forecasting models with a shorter time horizon** can better support operational decision making. Existing models can be further developed with subnational-specific data, and data access expanded through external partners. Satellite imagery can be utilized to cover gaps at subnational level data.
- **Decentralizing early action:** As mentioned, ECOWAS has facilitated the creation of national centers for response in each of its member countries. Previously, only the ECOWARN division in the Nigerian headquarters of ECOWAS had this capability. This decentralized EWEA approach has a mandate to alert the government of potential threats to human security; propose appropriate responses to identified threats; identify relevant response structures; and facilitate, coordinate, and monitor the implementation of response-related activities.

Open the path to knowledge, expertise, and resource sharing

As many interesting EWEA systems already exist, it is crucial to learn from them, put lessons

> *"There have been multiple efforts to use data and technology by variety of actors to develop and implement an early warning system. But I would like to recall what is the theme of this workshop – early warning/early action. Just as you have early warning as one side of the equitation, early action also needs to be developed, systematized and institutionalized."*
>
> — Rajkumar Cheney Krishnan
> United Nations Operations and Crisis Centre
> Information Management Officer

learned in a specific local context, and add technological approaches where the potential (and value) exists. Traditional data gathering for EWEA has often relied on manual collection of data, including from field monitors who record incidents and signals from the community. These approaches have been enhanced with the help of technologies allowing people to call in or send an SMS to share information.[36] The next wave of technological capabilities is allowing supplementary information to be automatically collected from online media or satellite imagery and processed through machine learning. This data boost has in turn facilitated the addition of **conflict modeling and prediction** to EWEA systems.

The challenge for many actors, however, remains moving beyond a "single data type analysis" and integrating different types of data into EWEA as one comprehensive picture. Another challenge is moving beyond mobile phones and the internet to integrate the potential of machine learning and AI.

Most emerging applications of new technologies come with exceedingly high costs that are not affordable to many organizations, even large agencies such as UNDP. The capacity for data-driven analysis is mostly in the hands of small groups of experts with coding or data science skills and access to high bandwidth and computer storage, or with access to large budgets and outsourcing capacities. Although big agencies often suffer from low levels of retention, they are still in a better position than smaller nonprofits (and even some governments) to explore and apply new approaches to conflict EWEA. However, the relevant knowledge and capacities they build are often locked inside their organizations, and systems are developed only for internal use. Hence, there is a need for improved ways to **share resources and democratize access** for broader use and application. Some organizations are opting to publish their work as open source, releasing their models for free and enabling others to choose elements useful to them.

For many organizations that lack experience or resources, initiating cooperation with others and utilizing these tools can be problematic. Gains from data science are often out of reach, especially for social impact organizations. Volunteers, interns, and partnerships with private sector data clinics present possibilities to utilize human capital and harness the potential of some of these technologies. Innovative hubs exist for connecting data scientists and field experts, working together through bottom-up collaboration. "Data for good" actors like Omdena are opening up new possibilities, organizing global "AI challenges" to bring ML and NLP knowledge and the expertise of hundreds of volunteer data scientists to organizations exploring the potential of advancing their work with data-driven approaches.[37]

> *"It's important that you don't reinvent the wheel – there's a lot that has already been done, already lots of open-source code that you can use and see if it fits and how you can adapt to."*
>
> — **Hadi Al Khatib**
> **Syrian Archive**

Ensure data ethics and responsibility in conflict EWEA

As open-source solutions like sharing data, models, and other technical capabilities become increasingly prominent, there is a need to balance privacy, data protection, and ethics issues. However, the EWEA field has no clear set of standards on data ethics and responsibility. Since the humanitarian field has been faster at responding to these challenges—and in general faster at combining new technologies and data in humanitarian action and relief—it is crucial to learn from these experiences and see how lessons learned can be put to potential use by the peacebuilding and prevention practitioners.[38]

Concerns include:

- lack of peer review, and work occurring in silos
- lack of agreement on accountability of different actors at the intersection of data science and humanitarian action
- issues around communicating complex processes and results
- how to include affected people and communities in the processes
- how to make the entire process transparent and build trust

These key insights led to a useful model for the EWEA field: the development of an **ethical framework** in 2020 by the Humanitarian Data Science and Ethics Group (DSEG), along with a **decision-making tree** to help stakeholders integrate ethics from the start and ultimately avoid "techno-solutionism." In this model, the data science lifecycle starts with fundamentals: humanitarian principles and ethics, AI ethics, data responsibility, human rights, and risk mitigation. The next step is problem and solution exploration, and then data collection and processing.[39]

One practical example of ethical approaches for the EWEA field relates to modeling migration and conflict. Early prediction and identification of migration flows can help to build humanitarian corridors in a timely manner. It can also help provide resources or

> *"This work is less and less and bright shiny object, and more and more about integration into decision support frameworks, and it's in those decision support frameworks that ethics happens. It's about the precautionary principle – new scientific processes and products should not be injected into ecosystems without sufficient evidence about what they will do…and that is the key to our primary humanitarian principle and that is the principle of humanity."*
>
> — Nathaniel Raymond
> Jackson Institute for Global Affairs

support migrant assistance centers. At the same time, it brings a risk of closed borders and antimigrant rhetoric, which may consequently harm already vulnerable populations. For these reasons, the Danish Refugee Council decided to withhold publication of some of their modeling work in an effort to protect affected communities.[40] This example demonstrates the importance of ethical approaches and shows that data science is not a purely technical discipline.

The potential future uses of analytics, insights, or training of models are very difficult to assess. We still lack evidence in this space on both positive and negative externalities. Positive effects and benefits are anecdotally understood, but not always well evidenced. Also, while ensuring data protection compliance, we should not replace ethics with data protection. Ethics should be at the core of humanitarian and peace-building and prevention work.

Build partnerships/alliances for early action

One recommendation to improve EWEA systems is to **create partnerships,** drawing upon diverse areas of expertise from different sectors and actors. Indeed, many successful EWEA projects are the result of a partnerships between sectors. One example is the Ethiopian Conflict Early Warning and Rapid Response (CEWRR), implemented as a partnership between the government, civil society, and local communities. A recent learning review of the pilot for this partnership highlighted that since the launching the upgraded CEWRR system (one year), a total of 166 conflict cases have been reported, with most of the conflict cases (58 percent) addressed and closed at the local level through community and government collaborative efforts. (It should be noted that this pilot has been implemented in the southern regional states of Oromia and Gambela, not in Tigray region where there has been a major conflict.)

Partnerships have proven useful in collecting and verifying data, including community participation at the local level, and they enable actors to coordinate, collaborate, and implement early and effective responses. Partnerships also strengthen monitoring and review of EWEA, and they increase accountability, integrity, and trust among involved partners and within the community itself. There is the potential of going a step further: **instead of partnerships, building alliances**—with agreed standards and common agreement on principles—allows allies to help each other when needed, and leverage each other's knowledge.[41] For many bigger actors, this entails the need to build **open-source solutions** to be shared with smaller actors.

> *"Building partnership and collaboration is key to strengthening early warning and response efforts and we hope to continue forging strong partnerships even after this workshop."*
>
> — **Esther Daramola**
> **ECOWAS**
> Early Warning Analyst on Governance and Human Rights

Partnership is also critical to financing EWEA initiatives, especially those that are global in scale and that provide a public good. It is important to avoid situations where public goods upon which many actors draw go unfunded—as was the case with the Global Terrorism Database for a one-year period. Thus, the UN, the Netherlands, US, and Germany have established the Complex Risk Analytics Fund (CRAF'd), recognizing not only the need to join forces in sharing expertise and knowledge, but also for funding and financing tools for data.

Develop localized EWEA systems and empower local communities to act

EWEA systems need to be **context-specific, demand- and user-driven**, developed **in cooperation with local communities,** and part of the communities which they intend to benefit. Many of the examples above already show a movement in this direction, from ECOWAS's establishment of national response centers in each of its member states, to the locally embedded approaches of Kivu Security Tracker and Ethiopian CEWRR.

This trend away from top-down and centralized early warning systems to more distributed and empowering models is the wave of the future in our increasingly interconnected world. The Sentinel Project, for example, focuses on building community-led misinformation management systems. Its "WikiRumours" software operates as an interactive mobile phone-based information service. A member of a given community can easily engage with the system through various channels, such as SMS, voice calls, social media, chatbots, mobile applications, project websites, and a network of trained volunteers called community ambassadors. The project team then verifies the rumor and sends a targeted update or "counter message" back to the community, with the aim of decreasing the spread of misinformation or disinformation. Similarly, Hagiga Wahid is an example of the implementation of WikiRumours in Uganda and South Sudan. This system can also serve as an early warning mechanism, indicating where ongoing violence is happening, notifying people of dangerous areas, and offering information about emergency services.[42]

Another EWEA model with strong emphasis on localized knowledge is The Dallaire Institute's approach to preventing recruitment of child solders. In this instance, big picture analysis enabled by data and modeling is complemented by localized understanding of the context of child recruitments.[43]

Integrating local communities as leaders in early warning is crucial for both data collection and effective early action. However, it is important to note that these systems are usually developed in volatile contexts where active participation may put individuals in additional danger. Ethical concerns must be kept paramount. The UN peacekeeping mission in Mali sees two potential solutions for this problem. The first option would provide a toll-free number only to village chiefs as those responsible to contact the mission. The second option would instead distribute the number widely through radio broadcasts to everybody in the country on the idea that if everybody knows the number, nobody will be in danger.[44]

Conclusion

Geospatial information technologies, remote sensing, machine learning, and natural language processing are all offering new avenues for EWEA data gathering, data processing, and conflict modeling. As the datasets become larger, processing data manually becomes a heavier and more time-consuming job. This is where ML becomes especially useful, processing millions of data points within short periods of time. Conflict and violence events can now be tracked from textual data utilizing different NLP techniques. Online news resources and social media data can be used to train models for conflict early warning signals. Next to these "high tech" approaches, many "low tech" solutions have also proven to have high impact in predicting conflict and saving lives—and, moreover, are sometimes more suitable for certain contexts.

The next generation of EWEA work, however, is more than the sum of these emerging technical solutions: it is also the recognition and practice of amplifying local voices and including localized and context-specific solutions. Joining forces between different stakeholders to create partnerships and establish systematic political processes is crucial to enabling better coordination and effective early action. At the same time, it is essential for all EWEA stakeholders to adopt ethical frameworks to guide their work and encompass ethics-by-design approaches in their work.

Endnotes

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