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Geospatial data as bioethical evidence

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Abstract

Satellite imagery now documents systematic patterns of infrastructure destruction at spatial resolutions and temporal cadences that were unavailable during the atrocities of the twentieth century. Whether and how such data may enter bioethical deliberation, however, remains under-theorized. Quantitative remote sensing produces damage percentages, not normative claims, and bridging the two without committing an is-ought fallacy requires an explicit epistemological procedure. The contribution developed here is normative and epistemological rather than empirical. A six-component admissibility framework integrates, for the first time, geospatial evidence, population-level bioethical principlism, and the coherentist verification epistemology of political fact-checking into a single reproducible procedure for the bioethical use of satellite imagery. The first component specifies evidence admissibility criteria tailored to bioethical rather than strictly legal use. The second requires coherentist triangulation across methodologically independent remote sensing studies. The third operates as a bioethical relevance filter mapping infrastructure categories onto population-level social determinants of health. The fourth operationalizes principlism by translating health justice, accountability, solidarity, and sustainability into measurable geospatial observables. The fifth establishes ethical representation safeguards against voyeuristic or dehumanizing uses of destruction imagery. The sixth demands explicit epistemic humility regarding uncertainty, data missingness, and attribution limits. The Gaza conflict provides the case in point. Two independently produced geospatial studies, one based on SAR coherent change detection and one on very-high-resolution optical analysis, converge on extensive damage to civilian healthcare, water, sanitation, and educational infrastructure, and thereby satisfy the coherentist triangulation requirement of the framework. The resulting inference licenses bioethical claims of systematic survival infrastructure degradation while preserving *transparent boundaries between what satellite evidence can and cannot establish about genocidal intent.*

Keywords: Satellite imagery, Bioethics, Systematic patterns, Fact-checking, Reproducibility, Data ethics, Humanitarian crisis, Gaza.

1. Introduction

Many people, from the general public to political commentators and public figures, are questioning whether the war in Gaza constitutes an act of genocide by the Israeli Defense Forces (IDF) against the Palestinian population. One thing must be clear: the concept of genocide has evolved and is not static. Lemkin (1933) first proposed "barbarity" as a crime encompassing acts of extermination against collective groups. By 1943, he coined "genocide", drawing from his analysis of the Armenian genocide and European colonization patterns (Lemkin, 1944). The 1948 United Nations (UN) Genocide Convention established the foundational legal definition focusing on "acts committed with intent to destroy, in whole or in part, a national, ethnical, racial or religious group"[1]. This framework, while narrower than Lemkin's original conception, established key criteria for evidence: demonstrable intent, systematic action, and targeting of specific groups.

Subsequent legal developments through international tribunals have expanded interpretative scope. For example, the International Criminal Tribunal for Rwanda (ICTR) and its Akayesu decision[2] established systematic rape as genocide when designed to prevent group births. The August 2001 Krstić ruling by the International Criminal Tribunal for the former Yugoslavia (ICTY) connected the concepts of ethnic cleansing, the use of rape as a weapon of war, and genocide in relation to the events that occurred in Srebrenica, a UN-designated "safe haven", in August 1995 (ICTY, 2001). The Serbian concept of "ethnic cleansing" (*etničko čišćenje*) emerged in the early 1990s as a state-sponsored policy designed to render areas of Bosnia and Croatia ethnically

[1] 1948 Convention on the Prevention and Punishment of the Crime of Genocide (the Genocide Convention): https://www.un.org/en/genocide-prevention/definition (accessed 28 April 2026).
[2] https://www.un.org/en/preventgenocide/rwanda/pdf/AKAYESU%20-%20JUDGEMENT.pdf (accessed 28 April 2026).

homogeneous by forcibly displacing non-Serbs, predominantly Bosniaks and Croats, in pursuit of a "Greater Serbia" (Lukić, 1994; Conversi, 2006). A factor too often forgotten is the complicity of the international community in enabling these crimes, a theme persuasively analysed in Simms (2002) and one that remains disturbingly relevant when assessing contemporary responses to Gaza. The use of rape in Srebrenica has been widely documented as a paradigmatic form of "systematic degradation of living conditions" and thus falls squarely within Article II(c) of the the Genocide Convention. The longer historical arc of such practices is laid out in the two-volume treatment by Levene (2013a, 2013b), whose work on "Devastation" and "Annihilation" provides the deeper historiographic grounding against which the present case must be read. In my reading, the ICTY's Krstic decision expanded the understanding of genocidal acts by establishing that "substantial" harm to protected groups includes systematic degradation of living conditions. This interpretation aligns with Article II(c) of the Genocide Convention regarding "conditions of life calculated to bring about physical destruction".

The legal plausibility of characterizing the situation in Gaza under the Genocide Convention has been judicially acknowledged at the highest level of international adjudication. On 26 January 2024, the International Court of Justice (ICJ), in Application of the Convention on the Prevention and Punishment of the Crime of Genocide in the Gaza Strip (South Africa v. Israel), issued provisional measures after finding that "at least some of the rights claimed by South Africa" under the Genocide Convention were plausible (ICJ, 2024a). The Court ordered Israel, inter alia, to take all measures within its power to prevent acts falling within Article II of the Genocide Convention and to ensure the provision of basic services and humanitarian assistance. Subsequent orders on 28 March and 24 May 2024 reaffirmed these measures and addressed the worsening humanitarian situation, including conditions described by the Court as the spread of famine (ICJ, 2024b, 2024c). It is important to clarify that the ICJ has not issued a final ruling on the merits: the case remains pending. This article does not adjudicate whether genocide has or has not occurred. Rather, it is proposed a methodological framework for gathering and analyzing the type of geospatial evidence that would be relevant to such legal determinations under the Genocide Convention's criteria.

In this article, it is shown how satellite imagery analysis serves as a critical tool for documenting genocide through systematic infrastructure destruction and its resultant bioethical implications. This methodology enables:

a) Infrastructure impact analysis
   - Systematic destruction of civilian facilities
   - Targeting of essential services
   - Pattern analysis of damage distribution

b) Living conditions assessment
   - Loss of shelter and housing
   - Disruption of medical facilities
   - Destruction of water and sanitation systems

c) Bioethical implications
   - Population exposure to extreme conditions
   - Denial of basic survival necessities
   - Cumulative health impacts from infrastructure loss

First, the documentation of coordinated attacks on civilian infrastructure through temporal analysis of satellite data. Second, the assessment of consequent humanitarian conditions through systematic monitoring of population displacement and access denial to essential services. Third, the establishment of bioethical evidence[3] by analysing how infrastructure destruction creates conditions incompatible with group survival. The term "bioethical evidence" used in this article does not imply deriving normative claims solely from empirical data (avoiding an is-ought fallacy[4]). Instead, it explicitly refers to empirical data relevant to ethical assessments, bridging the gap between facts and ethical evaluation. Drawing from Goldenberg's (2005) critique on evidence-based ethics, I argue that empirical evidence supports ethical reasoning by grounding it in objective reality without conflating facts with moral prescriptions. Thus, the concept of bioethical evidence used here provides rigorous, empirically verifiable documentation essential for ethical analysis of systematic harm. This framework contributes to the documentation of destruction patterns consistent with what the Genocide Convention terms 'conditions of life calculated to bring about physical destruction' (Article II(c)). It is important to note an epistemological caveat: geospatial data can document the systematic character of infrastructure destruction, but cannot, by itself, establish genocidal intent, a legal-psychological category that requires convergent evidence from multiple sources, including statements by decision-makers, military orders, and contextual analysis (Greenawalt, 1999). Satellite imagery constitutes one such evidentiary strand; its probative force lies in demonstrating the cumulative and patterned nature of destruction, not in directly evidencing *mens rea*". This methodological framework integrates established humanitarian data collection standards to ensure both empirical rigor and ethical

[3] In the context of this article, "bioethical evidence" is defined as empirical data that demonstrates systematic violations of established bioethical principles, particularly those affecting population health and survival. This definition builds upon foundational bioethical principles (e.g. autonomy, beneficence, non-maleficence, and justice) as applied to population-level health impacts. See, Daniels (2001), Landrigan et al. (2017), Heisler and Iacopino (2019).

[4] https://plato.stanford.edu/entries/hume-moral/ (accessed 28 April 2026).

compliance in documenting systematic infrastructure destruction. For example, this approach adheres to the Professional Standards for Protection Work (ICRC, 2024) which provides comprehensive guidelines for data collection in humanitarian contexts. These standards emphasize the critical balance between thorough documentation and the protection of affected populations, establishing clear protocols for data gathering that minimize potential harm while maximizing analytical value. The UN High Commissioner for Refugees (UNHCR) Data Collection Guidelines in Humanitarian Settings[5] inform this methodological approach to systematic documentation. The implementation of these guidelines ensures compatibility with established humanitarian protocols while maintaining methodological consistency across different analytical phases. The Digital Humanitarian Network provide crucial frameworks[6] for validating (even geospatial) data in crisis contexts. These standards inform the approach to cross-referencing satellite imagery with ground reports and open-source intelligence, establishing clear verification hierarchies and confidence levels in analysis. The implementation of these standards enables systematic assessment of evidence reliability while maintaining methodological transparency. The integration of these established frameworks, guidelines and standards manifests in four key methodological dimensions: 1) data collection ethics (strict protocols for gathering geospatial data that might reveal sensitive information about affected populations), 2) evidence verification protocols (multi-layered verification combining automated pattern recognition with human expert analysis), 3) protection of sensitive information (data protection protocols derived from International Committee of the Red Cross standards), and 4) documentation of systematic patterns (standardized reporting protocols enabling reproducible analysis while maintaining sensitivity to humanitarian concerns).

The urgency of this analytical framework that it is offered here is underscored by contemporary conflicts where systematic infrastructure destruction has become a primary tool of warfare. On establishing clear metrics for analysing satellite imagery, including temporal patterns of destruction, population displacement trajectories, and degradation of essential services, this methodology offers reproducible evidence for international legal proceedings. Moreover, the bioethical implications of infrastructure destruction provide objective documentation of how military operations can constitute genocide even without direct physical elimination of protected groups, thereby expanding our understanding of genocidal actions while maintaining rigorous standards of evidence. In the context of genocide documentation, physical mass elimination of protected groups is not the sole indicator of genocidal

[5] https://www.unhcr.org/handbooks/assessment/design/data-responsibility (accessed 28 April 2026).
[6] https://digitalhumanitarians.com/dhn/guidance/ (accessed 28 April 2026).

intent. Under Article II(c) of the Genocide Convention, the systematic destruction of civilian infrastructure, when coupled with consequent humanitarian crises and population displacement, can constitute evidence of "conditions of life calculated to bring about physical destruction". This broader interpretation is particularly relevant when analysing satellite imagery, which can document patterns of deliberate infrastructure targeting and their bioethical implications. The measurable consequences, including civilian casualties, collapse of healthcare systems, loss of shelter, and forced displacement, create conditions that threaten group survival through what has been termed "genocide by attrition" (Reeves, 2005), a concept consonant with the prosecution of Omar Hasan Ahmad al-Bashir, by the former Prosecutor Moreno Ocampo of the International Criminal Court (ICC), for deliberately inflicting on targeted Sudanese groups "conditions of life calculated to bring about their physical destruction" (ICC, 2008), and with his subsequent analysis of genocide through deliberate deprivation of essential resources in Nagorno-Karabakh (Moreno Ocampo, 2023). When these patterns are systematically documented through satellite evidence, they provide objective proof of actions designed to make life unsustainable for protected groups, thereby meeting the Genocide Convention's criteria for genocidal intent even absent mass direct killings.

In the following sections, this article develops a methodological framework for analysing satellite imagery as evidence of genocide through infrastructure destruction and its bioethical implications. The Theoretical Framework section establishes how satellite evidence fits within existing genocide definitions, particularly regarding "conditions of life" under Article II(c) of the Genocide Convention. It connects epistemological challenges in fact-checking with bioethical frameworks for documenting mass suffering. Methodological Approaches section presents protocols for systematic satellite analysis, including: verification standards for imagery interpretation, methods for documenting infrastructure targeting patterns, temporal analysis of destruction sequences, and population displacement tracking. The Bioethical Implications section examines how infrastructure destruction creates conditions threatening group survival. Finally, the Concluding Remarks section will recapitulate key ideas about how satellite imagery analysis provides empirical evidence of genocidal intent through systematic documentation of infrastructure destruction and its bioethical implications.

Before turning to the theoretical foundations, and in direct response to concerns that this article might read as a synthesis of Asi et al. (2024) and Forensic Architecture (FA)[7], it is worth stating up-front what is original here that is not in those sources, nor in Wiktor et al. (2024), nor in the independent satellite study

[7] https://forensic-architecture.org/ (accessed 28 April 2026).

of Perlman et al. (2025). This article contributes six items that, to the best of my knowledge, do not coexist in any prior work: (i) an explicit coherentist account of "bioethical evidence" as a category analytically distinct from legal, scientific, or journalistic evidence; (ii) a six-component admissibility framework mapping geospatial outputs onto the demands of bioethical deliberation; (iii) the concept of "systematic survival infrastructure degradation" as a bioethical category that is operationalizable through geospatial indicators; (iv) a crosswalk operationalizing Jecker et al.'s (2024) population-level bioethical principles via measurable geospatial observables; (v) a prospective, pan-conflict applicability that extends Wiktor et al.'s (2024) retrospective Rwandan bioethical analysis to ongoing emergencies where decisions about protection and accountability must be made in near-real time; and (vi) an explicit epistemological integration of reproducibility theory drawn from political fact-checking (Fernández-Roldán and Teira, 2024) into humanitarian geospatial verification. Asi et al. (2024) and Perlman et al. (2025) generate empirical substrate; Forensic Architecture supplies investigative protocols; this article articulates the normative grammar under which those outputs become admissible within bioethical reasoning without committing an is-ought fallacy. This is the original breakthrough: not new pixels, but the rules of inference that permit existing pixels to travel from remote sensing into population-level bioethics.

2. Theoretical framework

The framework consists of six components that differ from FA's investigative protocol in that they are oriented toward bioethical adjudication rather than legal forensics: (1) Evidence admissibility, criteria specifying when geospatial outputs may enter bioethical reasoning (sensor and source transparency, spatial resolution, temporal coverage, independent reproducibility, documented processing chain); (2) Coherentist triangulation, a requirement that bioethical claims rest on convergence between at least two methodologically independent remote sensing studies (e.g., Asi et al., 2024, using SAR coherent change detection and Perlman et al., 2025, using very-high-resolution optical imagery), cross-referenced with open-source intelligence and ground reports; (3) Bioethical relevance filter, a mapping from infrastructure categories onto the population-level social determinants of health articulated by Jecker et al. (2024), with minimum damage thresholds before a bioethical claim may be asserted; (4) Principlist operationalization, a crosswalk translating each population-level principle (health justice, accountability, solidarity, sustainability) into geospatial observables; (5) Ethical representation safeguards, protocols preventing voyeuristic or dehumanizing use of destruction imagery, including rules for image selection, redaction of locatable civilian features, and narrative contextualization; and (6) Epistemic humility, explicit statements of uncertainty, data missingness, and attribution limits, following Fernández-Roldán and Teira's (2024) coherentist account of reproducibility in political fact-checking. Components (1) and (2) are developed in Section 3 (Methodological Approaches); components (3)-(5) are developed in Section 4 (Bioethical Implications); component (6) runs throughout Section 3.1 (Methodological limitations). This architecture, specifically the integrated deployment of all six components, is the contribution of this article. No prior work combines them into a single, reproducible framework for bioethical use of geospatial evidence.

In this section, it is presented a methodological framework for analysing satellite imagery as evidence of systematic infrastructure destruction which serves as evidence to document systematic group harm. Drawing from the analysis of fact-checking protocols, it is proposed a comprehensive approach that balances rule-based and standard-based verification methods. This hybrid methodology enables reproducible documentation while maintaining the contextual understanding necessary for bioethical analysis. For the rule-based component of this framework, it is established strict verification protocols that ensure reproducibility of findings. These include standardized procedures for image analysis, quantifiable metrics for damage assessment, and clear criteria for pattern identification. This approach builds on the ICTY's precedent requiring "substantial" evidence of systematic harm, adapting it to satellite imagery analysis. But before presenting these approaches let's look at a brief introduction to the analysis of geospatial data with satellite imagery.

This theoretical framework draws on recent advances in humanitarian geospatial analysis. As Greenough and Nelson (2019) note, geospatial methods have evolved from simple mapping to sophisticated applications in humanitarian settings, including "tracking population displacement, conducting forensic analysis of attacks on health facilities, [and] developing early warning systems". This framework builds upon what Jabbour and Attal (2020) identify as an "underused remote method in humanitarian health research", extending it specifically to document systematic infrastructure destruction. This approach is particularly relevant when, as they note, "complexity and brutality of modern conflicts… pose threats to humanitarian providers and reduce access to affected communities" (Jabbour and Attal 2020), necessitating remote monitoring methods. It can be argued that geospatial analysis provides unique capabilities for documenting systematic destruction through what Jabbour and Attal (2020) term "integrating multiple georeferenced data sources". This integration enables documentation of patterns suggesting coordinated targeting rather than isolated incidents. However, as they caution, "outputs are as good as the inputs and assumptions" (Jabbour and Attal, 2020), requiring rigorous verification standards and explicit testing of analytical assumptions. This theoretical grounding supports this methodological approach of using geospatial analysis to document not just physical destruction, but also its systematic nature and bioethical implications. As humanitarian geospatial analysis evolves from basic mapping to "complex patterning and predictive modelling" (Jabbour and Attal, 2020), it provides increasingly sophisticated tools for documenting patterns of infrastructure destruction and their bioethical consequences.

The theoretical framework adopted in this analysis builds upon evolving methodologies in geospatial documentation while integrating bioethical considerations for humanitarian evidence. The investigation conducted by FA on the Israeli military's actions in Gaza since October 2023[8] provides a seminal example of how geospatial data can be systematically analysed to document infrastructure destruction and its bioethical implications. Their methodology integrates cutting-edge spatial analysis with a commitment to ethical principles, offering a comprehensive template for the type of verification standards and pattern documentation. Their development of the General Cartographic Database (GCD)[9] facilitates the categorization, mapping, and cross-referencing of thousands of verified incidents. Using temporal and spatial data points in conjunction, the GCD enables the identification of systemic patterns in attacks on civilian infrastructure, such as medical facilities, water systems, and housing. This aligns with the hybrid methodology proposed in this article, combining reproducibility through rigorous standards with contextual interpretation essential for bioethical analysis. The report establishes detailed protocols for verifying geospatial evidence, including cross-referencing satellite imagery with ground reports and open-source intelligence. Their iterative approach to data validation exemplifies the rule-based standards, ensuring that findings are reproducible and robust against epistemological challenges. Regarding FA, their rigorous methodology meets essential bioethical standards due to its transparent and accountable approach in documenting systematic harm. FA's methodology produces what Weizman (2017, pp. 18-22) terms 'material evidence', spatially grounded, publicly verifiable documentation that, while not value-neutral in the positivist sense, achieves epistemic robustness through triangulation of geospatial analysis, ground truthing, and open-source intelligence. The evidentiary status of such material evidence rests not on a naïve claim to objectivity but on its reproducibility and its amenability to independent verification (Weizman, 2017). This aligns closely with bioethical imperatives such as nonmaleficence, justice, and ethical representation of suffering, positioning their methods as ethically exemplary for documenting systematic harms in humanitarian contexts.

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[8] https://forensic-architecture.org/investigation/a-cartography-of-genocide (accessed 28 April 2026).
[9] https://forensic-architecture.org/methodology/visualization (accessed 28 April 2026).

To make the difference between the present framework and FA's investigative apparatus fully explicit, three novelties deserve emphasis. FA's GCD is designed for legal fact-finding and public accountability: it reconstructs incidents to support advocacy, litigation, and investigative journalism. It does not supply an ethical grammar under which geospatial outputs can be imported into bioethical deliberation. The framework in this article differs in three concrete respects. First, it articulates admissibility criteria tailored to bioethical (rather than strictly legal) use, drawing a deliberate distinction between evidence sufficient to adjudicate normative claims about population health and evidence sufficient to adjudicate criminal intent under the Genocide Convention: these are overlapping but not identical thresholds. Second, it imports coherentist verification norms from the philosophy of political fact-checking (Fernández-Roldán and Teira, 2024) into humanitarian geospatial practice; FA implicitly relies on a coherentist structure (triangulation of OSI, satellite, and ground reports) but does not theorize it. Third, it introduces the principlist bridge that connects geospatial outputs to Jecker et al.'s (2024) population-level bioethics, converting physical indicators (damage percentages, service-shed contraction, displacement trajectories, WASH-network integrity) into principle-relevant evidence (violations of health justice, accountability, solidarity, sustainability). FA's methodology is the closest extant model; the contribution here is the normative infrastructure that renders FA-style outputs usable in bioethical argumentation rather than only in legal argumentation.

3. Methodological approaches

To operationalize the theoretical framework outlined above, extensive use is made of the methodologies developed by FA in their investigation of systematic harm in Gaza. This section delineates specific techniques for documenting infrastructure destruction and displacement patterns, emphasizing reproducibility and ethical representation.

A clarification of the scope of this article's methodological contribution is warranted. This is not a remote sensing study: no original geospatial data analysis is performed, nor are novel satellite image processing techniques presented. The methodological contribution of this article is philosophical and normative. A framework is proposed that establishes criteria for how geospatial evidence of systematic infrastructure destruction should be gathered, verified, cross-referenced, and ethically evaluated, particularly when such evidence bears on determinations of genocidal intent under international law. The empirical foundations for this framework are provided by existing studies, principally the spatial analysis of Asi et al. (2024) and the investigative methodology of FA. The aim is to articulate the epistemological and ethical standards that should govern the production and use of such evidence for bioethical assessment and legal accountability.

Concretely, and to directly address the concern that this section may appear to duplicate Asi et al. (2024), what is new here and not present in their paper is the following. Asi et al. (2024) supply the quantitative spatial substrate: SAR-based coherent change detection on Copernicus Sentinel-1A imagery, Global Moran's I spatial autocorrelation analysis, and per-sector damage percentages for health, water, and educational infrastructure during the first phase of the campaign. They do not, and do not aim to, engage with bioethical theory; do not articulate admissibility criteria for non-legal normative use of their outputs; do not operationalize principlist population-level frameworks such as Jecker et al.'s (2024); and do not integrate their findings into the verification-epistemology literature (Fernández-Roldán and Teira, 2024). The original contribution of this article is the normative envelope that specifies three things absent in Asi et al. (2024): (a) under what conditions their statistical outputs (together with those of Perlman et al., 2025 on WASH infrastructure damage) may license claims about violations of population-level bioethical principles; (b) how convergence between independent geospatial studies, Asi et al. (2024) (SAR, health/water/education) and Perlman et al. (2025) (optical, WASH); functions as coherentist triangulation satisfying component (2) of the framework introduced in Section 2; and (c) how the resulting inference chain can inform bioethical deliberation without committing the is-ought fallacy. In a concise formulation, Asi et al. (2024) produce findings; this paper produces the inference rules under which such findings become bioethically admissible. Remove the framework and the findings remain valid as remote sensing; remove the findings and the framework remains valid as philosophy of bioethical evidence; only together do they yield population-level bioethical claims licensed by geospatial data.

FA employs a layered approach to verify geospatial data, combining Open-Source Intelligence (OSI), satellite imagery, and ground reports. This workflow enables rigorous cross-referencing, ensuring reliability in identifying destruction sites and displacement patterns. The FA's GCD serves as a central repository for verified incidents, categorizing them by type, location, and time.

Temporal data analysis is critical for distinguishing coordinated actions from isolated incidents. By comparing satellite imagery over sequential timeframes, FA identified progressive destruction patterns. For example, displacement trajectories showed a southward movement of civilians in Gaza, coinciding with the systematic targeting of northern infrastructure. FA highlights the interconnected impact of various types of destruction. For instance, the destruction of medical facilities exacerbates displacement by limiting access to healthcare in newly established humanitarian zones.

Mapping these cumulative impacts reveals how systematic harm unfolds on multiple levels, aligning with Article II(c) of the Genocide Convention. To uphold bioethical standards[10], FA emphasizes responsible representation of human suffering. This includes contextualizing destruction through qualitative narratives and avoiding dehumanization or desensitization in the visualization of trauma.

The satellite images presented in Figures 1 and 2 were obtained through EOSDA LandViewer[11], a web-based platform that provides access to multispectral satellite imagery from various sensors, including Sentinel-2 (European Space Agency, 10m spatial resolution in visible bands) and Landsat 8/9 (USGS/NASA, 30m spatial resolution). The images correspond to Gaza on 7 October 2023 and 15 November 2024, respectively. It is essential to clarify the evidential status of these images within the present article. They serve as visual illustrations of the scale and spatial extent of infrastructure destruction, providing temporal reference points that complement the quantitative spatial analysis conducted by Asi et al. (2024), who employed multi-temporal coherent change detection on Copernicus Sentinel 1-A Synthetic Aperture Radar (SAR) imagery with rigorous statistical methods including Global Moran's I autocorrelation analysis.

To directly address the concern that two optical scenes cannot rival the multi-site quantitative cartography of Asi et al. (2024), it has to be highlighted that the role of Figures 1 and 2 in this article is pedagogical, not evidential. Their function within the framework set out in Section 2 is to illustrate component (1), the distinction between "illustrative optical imagery" (admissible for orienting a reader, inadmissible for grounding bioethical claims) and "quantitative remote sensing outputs" (admissible, subject to independent reproduction, for bioethical adjudication). The figures therefore do not complement Asi et al. (2024)'s analysis in the sense of adding evidentiary weight; they complement it pedagogically by showing the lower evidential tier that, on its own, would be insufficient. They thereby motivate and anchor component (2), the coherentist requirement that bioethical claims rest on convergence between at least two methodologically independent quantitative studies. That convergence is now empirically available, say, independently of Asi et al. (2024), who used SAR coherent change detection. For instance, Perlman et al. (2025) identified 239 WASH sites across the Gaza Strip and documented damage at 49.8% (n = 119)

[10] The bioethical standards to which FA's methodological framework of "counter-forensics" adheres (see Weizman, 2019, Open Verification, e-flux Architecture, retrieved from https://www.e-flux.com/architecture/becoming-digital/248062/open-verification/, accessed 28 April 2026) are human dignity and justice. These standards encompass three key dimensions: methodological ethics (the systematic documentation of infrastructure destruction and the targeting of health systems), representational ethics (rigorous verification protocols and the ethical presentation of evidence), and investigative ethics (open-source methods and reproducible protocols).

[11] https://eos.com/es/ (accessed 28 April 2026).

of them through analysis of very-high-resolution optical imagery, a finding broadly consistent with the 42.1% water-facility damage reported by Asi et al. (2024) using a different sensor modality and a different analytical pipeline. The coherence of two methodologically independent remote sensing studies is precisely the epistemic structure my framework requires before bioethical claims are licensed. Figures 1 and 2 illustrate the raw material on which that coherentist structure operates; they do not and cannot substitute for it.

Coherentist triangulation is in fact considerably stronger than the two-study convergence sketched above. At least four methodologically independent remote sensing investigations of Gaza can now be placed alongside one another, each employing a different sensor modality, a different analytical pipeline, and a different infrastructure target domain, and each reaching conclusions consistent with a pattern of systematic rather than collateral destruction. Asi et al. (2024) used Sentinel-1A SAR coherent change detection to quantify damage to health, water, and educational

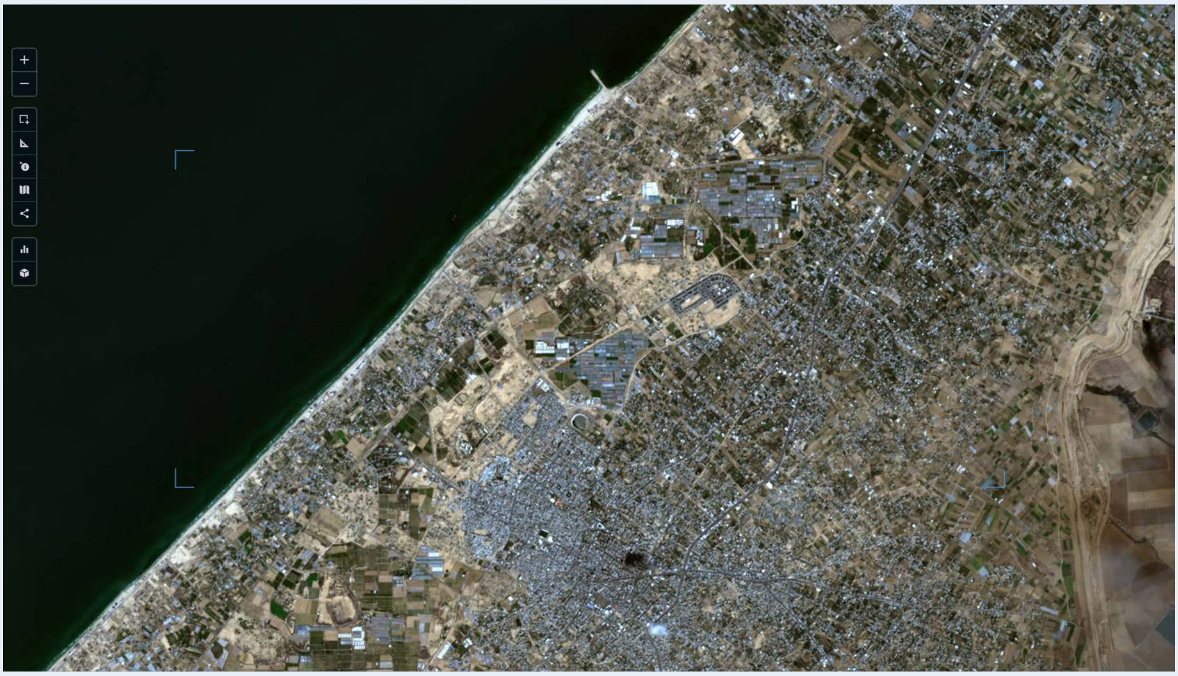

Figure 1. *Satellite imagery of Gaza dated 7 October 2023 (source: EOSDA LandViewer; approximate sensor: Sentinel-2, 10m resolution). The image captures the pre-conflict urban and agricultural landscape with structures and farmlands intact. This baseline provides the temporal reference point for assessing the scale of subsequent destruction.*

Figure 2. *Satellite imagery of Gaza dated 15 November 2024 (source: EOSDA LandViewer; approximate sensor: Sentinel-2, 10m resolution). The image reveals extensive infrastructure destruction concentrated in urban and agricultural zones. The visual contrast with Figure 1 illustrates, though does not quantify, the scale of damage documented quantitatively by Asi et al. (2024), who reported damage to 60.8% of health facilities, 68.2% of educational facilities, and 42.1% of water infrastructure during the first phase of the military campaign alone.*

infrastructure during the first phase of the campaign. Perlman et al. (2025) used very-high-resolution optical imagery to quantify damage to WASH infrastructure across 239 catalogued sites. Yin et al. (2025) employed PlanetScope and SkySat imagery to evaluate war-induced damage to agricultural land in the Gaza Strip, documenting the collapse of food-producing capacity over successive image epochs. A 2025 study published in Global Environmental Change combined Sentinel-5P retrievals with machine learning to quantify post-October 2023 air pollution over Gaza (Abulibdeh, 2025), revealing atmospheric consequences of the bombing campaign that extend beyond the footprint of any single damaged structure. The convergence of four studies, using four different sensors, four different analytical methods, and four different infrastructure or environmental domains (built health/water/education, WASH, agriculture, atmosphere), is a strong instance of the coherentist triangulation required by component (2) of the framework. Under component (2), no single study, nor the mere visual contrast of Figures 1 and 2, licenses the bioethical claims advanced in Section 4; it is their joint convergence that does so.

The temporal comparison between the satellite images from 7 October 2023 (Figure 1) and 15 November 2024 (Figure 2) provides stark visual evidence of systematic destruction in Gaza. The visible damage in the November image, characterized by extensive darkened areas and disruptions in the urban layout, indicates the deliberate targeting of civilian infrastructure, including homes, roads, and agricultural zones. The progression of destruction aligns with patterns identified in FA's analysis, where the systematic targeting of infrastructure compounds the humanitarian crisis. These patterns disrupt access to essential services such as healthcare, water, and shelter, creating what the Genocide Convention refers to as "conditions of life calculated to bring about physical destruction". This analysis underscores the bioethical imperative of documenting such events to reveal the human cost of sustained infrastructural harm and its impact on population displacement and survival.

Platforms such as EOSDA LandViewer facilitate visual comparison of pre- and post-destruction phases, making the broad extent of infrastructure damage visible. However, rigorous damage quantification requires the application of dedicated remote sensing methodologies, such as the SAR-based coherent change detection employed by Asi et al. (2024), rather than visual inspection of optical imagery alone. The photograph is a useful tool for evidentiary purposes in documenting humanitarian situations with bioethical significance because of its repeatability and clarity. Drawing on the insights from Fernández-Roldán and Teira (2024)'s analysis of reproducible fact-checking protocols, the focus will be on the epistemic underpinnings and methodological challenges of reproducibility in geospatial analysis, while also incorporating bioethical principles for humanitarian documentation. The methodological framework for analysing satellite imagery as evidence of systematic group harm requires balancing two critical components: reproducibility and contextual flexibility. As Fernández-Roldán and Teira (2024) highlight, reproducibility is foundational to establishing epistemic trust in any verification process, yet it must contend with the interpretative nuances inherent in complex datasets. This framework outlines a hybrid approach that integrates rule-based protocols for objective verification with standard-based interpretative frameworks to ensure ethical and contextual sensitivity.

Building on the analogy with fact-checking protocols, satellite imagery analysis must adopt strict rule-based verification methods to achieve reproducibility. These methods should include standardized criteria for image selection. Just as fact-checkers define verifiable claims based on reach and importance, satellite analysts must establish clear guidelines for selecting images. Temporal relevance (Daoud and Huang, 2013), geospatial focus (Butkiewicz et al., 2008), and resolution quality (Zhan et al., 2005) should form the basis for inclusion. Following the methodology set out here, the analytical framework developed by Asi et al. (2024) is significantly extended, with substantial enhancements in temporal analysis, verification protocols, and pattern recognition capabilities. If implemented, these proposed advances would collectively enable more robust and reproducible documentation of systematic infrastructure destruction patterns while maintaining rigorous analytical standards.

In the domain of temporal analysis, the proposed framework calls for the implementation of multi-temporal image sequencing techniques that would enhance the capability to track infrastructure destruction patterns over time (Degbelo and Kuhn, 2018). The verification protocol extensions represent another significant methodological advance. This framework proposes the development of cross-reference mechanisms that would systematically integrate ground reports with satellite imagery analysis, enabling multi-dimensional verification of observed destruction patterns. These methodological advances collectively enhance the ability to document systematic patterns of infrastructure destruction while maintaining strict reproducibility standards. The integration of enhanced temporal analysis, robust verification protocols, and advanced pattern recognition capabilities provides a more comprehensive framework for analysing and documenting systematic infrastructure targeting patterns. Furthermore, damage must be quantified using consistent metrics, similar to truth scales in fact-checking. Metrics such as percentage of area destroyed or building counts must be explicitly calibrated and publicly accessible to allow independent replication. Stepwise documentation protocols are also critical. Inspired by the International Fact-Checking Network's insistence on public archives, satellite analysis should document every step of the verification process, including data sources, analytical methods, and assumptions. At the same time, as Fernández-Roldán and Teira (2024) argue, rigid rule-based systems risk oversimplifying complex phenomena. In the context of satellite imagery, this rigidity must be counterbalanced by flexible, standard-based protocols that allow for interpretative judgment. Analysts must interpret the spatial distribution of destruction in light of geopolitical and historical contexts.

For example, the concentration of attacks on civilian infrastructure in Gaza suggests intentional targeting rather than collateral damage (Asi et al., 2024). To mitigate biases in satellite interpretation, corroborative evidence from ground reports and open-source intelligence must inform the analysis. This hybrid approach ensures that visual data is not decontextualized from its human and bioethical impact. Unlike political fact-checking, geospatial analysis for humanitarian crises raises profound bioethical considerations. These challenges necessitate ethical representation of suffering. I will talk more about this in the next section. Visualizations must avoid

desensitization by incorporating narratives that humanize the impacted populations. Transparent methodologies are also essential.
Following the International Fact-Checking Network's call for transparency, all assumptions, limitations, and potential biases in satellite analysis must be disclosed. Moreover, reproducibility in this context is not merely an epistemic standard but a safeguard against politicized misrepresentation of bioethical and humanitarian evidence of systematic harm against a group. As Fernández-Roldán and Teira (2024) suggest, reproducibility alone does not guarantee epistemic validity. In satellite imagery analysis, this principle extends to the integration of bioethical considerations. While rule-based protocols anchor objectivity, standard-based methods ensure that the analysis remains sensitive to the complexities of human suffering.

3.1. Methodological limitations

The proposed framework, while robust in its approach to systematic documentation, faces several significant methodological limitations that require careful consideration. The temporal resolution constraints present a fundamental challenge in geospatial analysis (Degbelo and Kuhn, 2018). Commercial satellite imagery typically provides snapshots at intervals that may miss crucial transitional moments in infrastructure destruction. This temporal gap can obscure the precise sequence of events, potentially affecting our understanding of systematic patterns. For instance, in analysing destruction sequences in urban areas, the available imagery might capture the initial and final states but miss intermediate stages that could provide crucial evidence of coordinated actions or systematic targeting patterns.
Environmental factors introduce another layer of complexity in data collection and analysis. Atmospheric conditions, particularly cloud cover and atmospheric haze, can significantly impact image quality and temporal consistency. This limitation becomes particularly acute in regions experiencing seasonal weather patterns or during periods of intense military activity when smoke and debris can obscure satellite views. These environmental interference patterns can create systematic gaps in documentation, potentially biasing the analysis toward periods of clear atmospheric conditions. The challenge of ground verification represents a critical limitation in the methodology particularly in conflicts like Gaza where there is a near-total ban on international journalists and even NGO professionals entering Gaza (UN, 2024). While satellite imagery provides valuable macro-level evidence, the inability to consistently verify observations through ground-truth data introduces uncertainty in damage assessment and pattern identification. This limitation becomes especially important when trying to confirm certain kinds of infrastructure damage

or when evaluating the operational state of buildings that can seem intact from the outside but aren't working because of inside damage. Attribution challenges present perhaps the most complex methodological limitation.

While this framework can document patterns of destruction with high spatial and temporal precision, establishing direct causal links between observed damage and specific actors remains problematic. However, in the case of Gaza, multiple independent investigations have attributed the destruction of civilian infrastructure to Israeli military operations. The Independent International Commission of Inquiry on the Occupied Palestinian Territory, including East Jerusalem, and Israel[12] concluded that Israel committed acts constituting war crimes, including the deliberate targeting of civilian objects (UN Human Rights Council 2025 A/HRC/59/26[13]). The spatial distribution of damage documented by Asi et al. (2024) is consistent with the known trajectory of IDF ground and aerial operations, and the ICJ's provisional measures orders (ICJ, 2024a, 2024b, 2024c) were predicated on the plausibility of claims attributing acts under Article II of the Genocide Convention to Israel. Urban density introduces specific technical and analytical challenges, as it is the case in Gaza, that affect the methodology's precision. In densely populated areas, as Gaza, the vertical stacking of infrastructure and the complexity of urban networks can obscure damage patterns visible from satellite perspectives. Underground infrastructure, internal damage to multi-story buildings, and the interconnected nature of urban services create analytical blind spots that this methodology cannot fully address. This limitation particularly affects the ability to assess the full scope of infrastructure damage in urban cores where multiple systems may be affected by single incidents. These methodological limitations necessitate a nuanced approach to data interpretation and analysis. Several strategies to mitigate these limitations are proposed: first, explicit documentation of temporal gaps in analysis; second, development of statistical methods to account for systematic biases in data collection; third, integration of multiple data sources to compensate for single-source limitations; and fourth, clear acknowledgment of uncertainty levels in findings. These strategies allow to maintain methodological rigor while being transparent about the limitations of the approach. A further caveat belongs here: because the contribution of this article is normative and epistemological rather than empirical, the Figures 1 and 2 presented above serve as illustrative material only. Any concrete empirical application of the framework to a specific conflict, and in particular any adjudication of bioethical claims about Gaza using geospatial data, should be accompanied by

[12] https://www.ohchr.org/en/hr-bodies/hrc/co-israel/index (accessed 28 April 2026).
[13] https://www.un.org/unispal/document/report-of-the-independent-international-commission-of-inquiry-on-the-occupied-palestinian-territory-including-east-jerusalem-and-israel-a-hrc-59-26/ (accessed 28 April 2026).

an independent interpretation of the underlying remote sensing outputs by a qualified satellite imagery expert. The four independent studies on Gaza converged upon in Section 3 (Asi et al., 2024; Abulibdeh, 2025; Perlman et al., 2025; Yin et al., 2025) all meet this requirement, since each was produced by specialists working under peer review; the illustrative figures in this paper do not. The admissibility criterion of component (1) is therefore satisfied by those four studies, not by the Figures 1 and 2 in this article.

4. Bioethical implications

The systematic documentation of infrastructure destruction through satellite imagery raises critical bioethical concerns regarding both evidence collection and humanitarian impact. It is argued that the destruction of civilian infrastructure creates conditions that threaten not just immediate survival but long-term population health and welfare. The quantitative data cited in this section, including damage estimates for healthcare, water, and educational infrastructure, are drawn from the spatial analysis conducted by Asi et al. (2024), who applied coherent change detection on SAR imagery and verified their findings using geocoded data from OCHA, OpenStreetMap, and the Humanitarian OpenStreetMap Team. The present article does not produce independent quantitative data but uses their empirically grounded findings as the evidential basis for the bioethical framework proposed here. This raises the question of what this section adds beyond Wiktor et al. (2024), whose bioethical analysis of postwar Rwanda remains retrospective and context-specific. Three differences deserve to be stated plainly. First, scope: Wiktor et al. (2024) analyse a closed historical episode, drawing normative conclusions from post-hoc epidemiological and qualitative data. The framework proposes is prospective and pan-conflict, designed to operate on streaming geospatial outputs during ongoing emergencies when decisions about protection, humanitarian corridors, and international accountability must be made in near-real time. Second, evidentiary architecture. Wiktor et al. (2024) rely on retrospective qualitative and epidemiological sources; the framework here specifies how geospatial outputs, which were simply not available for Rwanda at the spatial resolution and temporal cadence now accessible, can feed bioethical deliberation contemporaneously with the events under consideration. Third, integration. Wiktor et al. (2024)'s analysis is not articulated with principlist population-level bioethics (Jecker et al., 2024), with the coherentist verification epistemology of Fernández-Roldán and Teira (2024), or with remote sensing methodology (Asi et al., 2024; Perlman et al., 2025). The Section 4 supplies precisely this integrative crosswalk. The contribution therefore complements, rather than duplicates, Wiktor et al. (2024): their retrospective Rwandan insights motivate the concern; the framework proposed in this article generalizes that concern into a prospective, operationally specified procedure for evaluating ongoing conflicts through geospatial evidence.

The bioethical implications of infrastructure destruction manifest in several critical dimensions. First, the systematic targeting of healthcare facilities, as evidenced by spatial analysis documenting damage to 60.8% (n = 59) of health facilities during the first phase of the military campaign alone (Asi et al., 2024), leads to what the UNHCR terms “complex emergencies”. When hospitals and medical centres are destroyed, it eliminates not just immediate care capabilities but creates long-term conditions incompatible with population health maintenance. This aligns with Asi et al. (2024)’s findings of “widespread damage to critical civilian infrastructure that should have been provided protection under IHL”.

Second, the destruction of water infrastructure and educational facilities compounds these health impacts. The analysis demonstrates that 42.1% (n = 64) of water facilities sustained damage (Asi et al., 2024), creating conditions that the ICTR has previously recognized as “calculated to bring about physical destruction”. The lack of clean water access and sanitation directly threatens population survival, while the destruction of schools (affecting 68.2% of facilities: Asi et al., 2024) eliminates safe spaces for children and creates lasting psychological trauma. The bioethical implications extend beyond immediate physical harm. As demonstrated in Rwanda’s post-genocide studies (Wiktor et al., 2024), systematic infrastructure destruction creates intergenerational trauma that manifests in both psychological and physiological effects. The spatial patterns of destruction that multiple investigations are documenting in the war of Gaza suggest similar systematic targeting that could produce long-term collective trauma among affected populations with everlasting bioethical implications. The systematic targeting and destruction of critical civilian infrastructure in Gaza, as revealed by geospatial data, raise profound bioethical implications. The destruction is not only immediate and physical but reverberates through long-term societal and health dimensions, creating conditions that threaten the survival of the entire population. It is a humanitarian catastrophe. This deliberate creation of life-incompatible environments highlights the dual role of bioethics in documenting harm and advocating for the ethical use of evidence.

To render this section operational rather than programmatic, and to supply an item absent both from Asi et al. (2024) and from Wiktor et al. (2024), a minimal crosswalk between Jecker et al.’s (2024) four population-level bioethical principles and measurable geospatial indicators is proposed. This crosswalk is component (4) of the framework introduced in Section 2. Health justice is operationalized by the per-capita service-shed of functioning healthcare facilities, derivable from dated damage catalogues (Asi et al., 2024) cross-referenced with WorldPop[14] or equivalent population rasters; a bioethical claim of health-justice violation becomes licensed when the service-shed contracts below an agreed threshold relative to a pre-conflict baseline. Accountability is operationalized by the temporal coincidence between named military operations and damage-onset timestamps extractable from multi-temporal imagery; temporal alignment above chance, when reproducibly documented, supports an accountability claim without requiring independent adjudication of intent. Solidarity is operationalized by the degree of international verification convergence across independent geospatial studies, for example, the Asi-Perlman convergence discussed in Section 3 is a concrete instance, and by public availability of underlying data for third-party replication. Sustainability is operationalized by the cumulative degradation of water, sanitation, agriculture, and food-production infrastructure over successive image epochs since sustainability concerns the capacity of the affected population to maintain the conditions of life after hostilities end. The novelty here lies neither in the principles themselves, which are Jecker et al.'s (2024), nor in the underlying imagery, which is produced by Asi et al. (2024), Perlman et al. (2025), and FA, but in the explicit translation rule that allows principle-level ethical judgments to be grounded in reproducible spatial observables. Without such a translation rule, bioethical invocations of principles in conflict contexts remain largely rhetorical; with it, they become testable, open to critique, and revisable in light of new imagery.

4.1. Ecocide as a complementary category: The environmental dimension of systematic survival infrastructure degradation

The sustainability principle just operationalized forces a conceptual extension that deserves separate treatment. If sustainability concerns a population's capacity to maintain the conditions of life after hostilities end, then its violations cannot be confined to built infrastructure alone. Contemporary conflicts generate atmospheric, pedological, hydrological, and climatic harms whose footprints are themselves observable from orbit and whose long-run bioethical weight is comparable to that of direct civilian casualties. The recent literature on the environmental consequences of armed conflict in Gaza (Hassoun, 2025) and on the war-damage record reconstructed from time-series satellite imagery, including the detection of thousands of missile craters that serve as a proxy for unexploded ordnance locations (Holalil et al., 2024), documents how ecological destruction, soil contamination, disruption of agricultural cycles, and long-tail chemical exposure

[14] https://www.worldpop.org/ (accessed 28 April 2026).

reconfigure the survival horizon of civilian populations for decades after a ceasefire. Air-pollution burden estimated from machine-learning analyses of satellite-derived aerosol retrievals over post-October 2023 Gaza (Abulibdeh, 2025) converges with ground-level health harm, and agricultural damage detected by PlanetScope and SkySat (Yin et al., 2025) converges with projected food-security collapse. The same admissibility framework articulated in Section 2 therefore licenses a second bioethical category, complementary to genocide under Article II(c) of the Genocide Convention, namely ecocide understood as the large-scale, systematic, and reasonably foreseeable destruction of the ecological substrate on which a civilian population depends. Treating ecocide as complementary rather than derivative matters because the temporal scale of ecological harm outstrips the temporal scale of most legal inquiries, which means that a framework restricted to immediate built-environment damage will systematically under-weight precisely those harms that compromise long-run survival. The link between war, nationalist mobilization, environmental destruction, and climate vulnerability is explicitly theorized by Conversi (2020), whose analysis of nationalism as a driver and obstructor of climate action provides the conceptual bridge between an individual conflict episode and the planetary-scale sustainability claim that the sustainability principle requires. Recognizing ecocide alongside the Article II(c) reading of systematic survival infrastructure degradation therefore does not dilute the genocide analysis; it completes it by closing the temporal and ecological gap that a built-environment-only reading would leave open.

5. Concluding remarks

This narrative analysis demonstrates how satellite imagery can provide systematic documentation of infrastructure destruction through rigorous methodological frameworks with bioethical implications. The patterns revealed through geospatial analysis suggest coordinated actions that create conditions threatening group survival through what may be termed "systematic survival infrastructure degradation". This concept is introduced to denote the coordinated and progressive destruction of the ensemble of civilian infrastructure essential for group survival, including healthcare, water, sanitation, shelter, and education systems. It is analytically distinct from "collateral damage" in that it emphasizes the systematic and cumulative character of destruction, which, when documented through geospatial evidence, may constitute evidence of "conditions of life calculated to bring about physical destruction" under Article II(c) of the Genocide Convention. The evidence presented shows clear patterns that extend beyond isolated military incidents. The systematic nature of infrastructure destruction, particularly the statistically significant clustering of damage around healthcare facilities, water systems, and educational institutions, suggests coordinated actions creating conditions incompatible with bioethical welfare. The spatial analysis reveals targeting patterns that, when combined with temporal sequences and population displacement data, provide objective evidence of actions designed to make territories uninhabitable.

Of particular concern is what the data reveals about the systematic degradation of essential services. The destruction of healthcare infrastructure (60.8% of facilities damaged), combined with water system targeting (42.1% of facilities damaged) and educational institution destruction (68.2% of facilities impacted), all figures from Asi et al. (2024), covering only the first phase of the military campaign (7 October to 22 November 2023), creates conditions that the Genocide Convention terms "calculated to bring about physical destruction".

These patterns mirror historical cases where infrastructure destruction was used to create conditions threatening bioethical welfare, as documented in Rwanda and Bosnia. The bioethical implications of this systematic infrastructure destruction extend beyond immediate casualties. The targeting of healthcare systems, water infrastructure, and educational facilities creates cascading humanitarian impacts that threaten population survival through "genocide by attrition" (Reeves, 2005), a pattern consonant with the legal framework applied by the ICC in the Al-Bashir case (ICC-OTP, 2008). The evidence suggests the creation of conditions that make civilian life unsustainable, a pattern that merits urgent international attention. The systematic nature of infrastructure destruction raises fundamental questions about the international community's responsibility to protect civilian populations from the creation of conditions that constitute systematic bioethical violations through denial of fundamental human necessities for life. The deliberate destruction of critical infrastructure and the subsequent deprivation of essential services observed in Gaza reflects a broader and troubling trend identified in war-affected zones globally. As bioethicists Jecker et al. (2024) highlight, war is not merely a collection of isolated military engagements but a public health crisis that systematically erodes the 'Social Determinants of Health' (SDoH), including access to clean water, food security, healthcare, and education. Furthermore, the adoption of Jecker et al.'s (2024) expanded bioethical principles for humanitarian crises does not contradict the traditional four principles[15] of clinical ethics by Beauchamp and Childress (1997) (autonomy, beneficence, nonmaleficence, justice). Rather, these principles are complementary, extending principlism from individual-level ethical considerations to population-level ethical issues that arise specifically in armed conflicts and

[15] https://bioethics.pitt.edu/sites/default/files/Stott%2C%20Chapter%203%20Beauchamp.pdf (accessed 28 April 2026).

humanitarian crises. As Jecker et al. (2024) highlight, principles like health justice, accountability, and public health sustainability reinforce traditional bioethics by addressing collective harms and responsibilities in complex crisis settings, thus ensuring ethical analysis remains comprehensive and contextually relevant.

The systematic nature of this destruction in Gaza, as evidenced through geospatial analysis, mirrors historical cases where targeted infrastructure degradation was utilized as a weapon to undermine civilian resilience and survival. Public health research demonstrates that the destruction of SDoH creates a “syndemic” effect, where interconnected factors such as malnutrition, waterborne diseases, and lack of medical care exacerbate vulnerabilities (Jecker et al., 2024). In this context, the destruction documented through geospatial analysis in Gaza highlights an urgent need for a bioethical reevaluation of how wars are conducted and their impact on civilian populations. Satellite imagery not only provides objective evidence of systematic harm but also underscores the (bio)ethical responsibilities of both local actors and the global community to address the cascading effects of war. Geospatial analysis, rooted in rigorous epistemic criteria for evidence-based data verification, emerges as a powerful and unequivocal form of evidence to reveal and address critical bioethical implications.

Three final implications deserve explicit statement. First, the historical arc traced by Levene (2013a, 2013b) in his two-volume study of devastation and annihilation, together with the genealogy of “ethnic cleansing” (*etničko čišćenje*) foregrounded in Section 1 and the complicity of the international community in enabling mass violence analysed by Simms (2002), places the Gaza case in continuity with earlier episodes of systematic civilian destruction rather than in exceptional isolation. That continuity is not a rhetorical device; it is the empirical warrant for treating “systematic survival infrastructure degradation” as a recurrent modality of Article II(c) of the Genocide Convention violations rather than as an ad hoc descriptor of a single conflict. Second, the ecocide extension developed in Section 4.1 means that the bioethical ledger of contemporary conflicts must include atmospheric, pedological, and climatic harms whose magnitude is increasingly documentable through remote-sensing pipelines (Holail et al., 2024; Abulibdeh, 2025; Hassoun, 2025; Yin et al., 2025;). Conversi’s (2020) analysis of nationalism and climate change clarifies why these harms are not peripheral: the same nationalist mobilizations that license the violent reshaping of human geographies also obstruct the climate action required to repair the ecological geographies they damage, and the two scale together. Treating the sustainability principle as a genuine bioethical constraint therefore entails treating ecocide as a live category, verifiable from orbit, and admissible under the same six-component framework proposed in Section 2. Third, the admissibility framework is designed to be portable. Nothing in its formulation is Gaza-specific; the coherentist convergence across Asi et al. (2024), Perlman et al. (2025), Yin et al. (2025), and Abulibdeh (2025) supplies a replicable template that can and should be applied to other theatres in which systematic survival infrastructure degradation is suspected. Geospatial bioethics, in the sense defended here, is therefore neither a metaphor nor a synthesis of prior work but a normative epistemology, one that closes the gap between the imagery the world already possesses and the ethical and legal judgments the world has so far been unable, or unwilling, to ground in it.

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