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Article

Designing a general economic model to incentivize maintaining infrastructure in informal settlements

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Abstract: This paper sketches the design for a general economic model (GEM) quantifying how informal settlements (also known as slums) function and interact with ancillary urban or rural regions. The GEM is an essential tool for calculating the incentive fee payable to residents of the informal settlement to maintain housing, healthcare, schools, water, sanitation, or other infrastructure improvements and investments made by third parties and to identify potential payors or funders of the incentive fee. It is suggested that the GEM resolve limitations of traditional cost-benefit analyses (CBAs) in order to better calculate such incentive fee amounts and ascertain the parties willing to pay them. To understand how the GEM fills data gaps and helps fund national commitments to the United Nations 2030 Sustainable Development Goals (SDGs), the financial constraints on two countries, Fiji and Indonesia, as exacerbated by the Coronavirus COVID-19, and Indonesia's village finance modernization scheme (Siskeudes) are discussed.

Keywords: periodic table of quality of life; slums; sustainable finance; sustainable development goals

1. Introduction

Urbanization is changing the geography of our planet. Today, more than 50% of the global population lives in cities; by 2100, 85% will live there [1].

Between 1970 and 2050, the percentage of people living in cities and elsewhere traded places, doubling urban issues and challenges (**Figure 1**) [2]. Cities designed in the 19th and 20th centuries were not built to feed, house, employ, transport, deliver clean water and sanitation, and adapt their buildings, infrastructure, governmental operations, and judicial and taxation practices to accommodate such rapid growth.

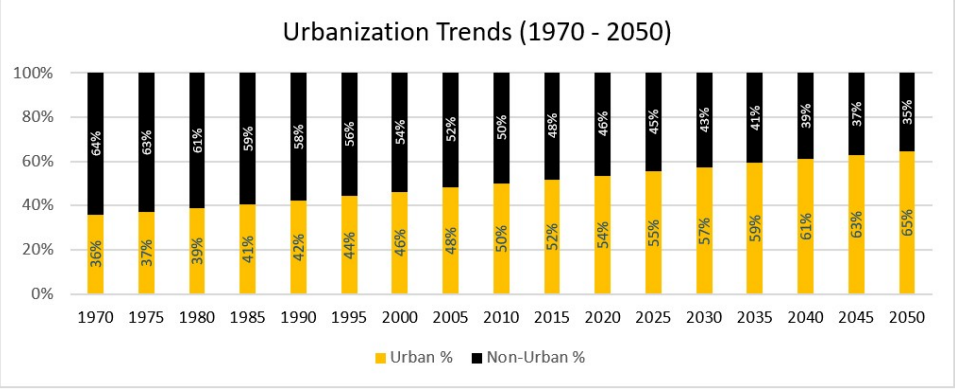

Figure 1. Urbanization trends (1970–2050).

By its nature, to date, urbanization creates and reinforces stratification amongst socioeconomic and cultural drivers of inequality. Informal settlements (also known as slums) form in land initially lower in market value or utility and without land tenure [1]. Slums house marginalized urban or rural residents, cultures or those in economic or social poverty, in varying proportions regionally (**Figure 2**) [3,4]. Taken in the aggregate, global urban slum populations are declining, but severe regional conditions persist. Today, 20% of the global population—exceeding 1 billion people—lives in urban slums [5] on less than USD$3.20 per day [6–8].

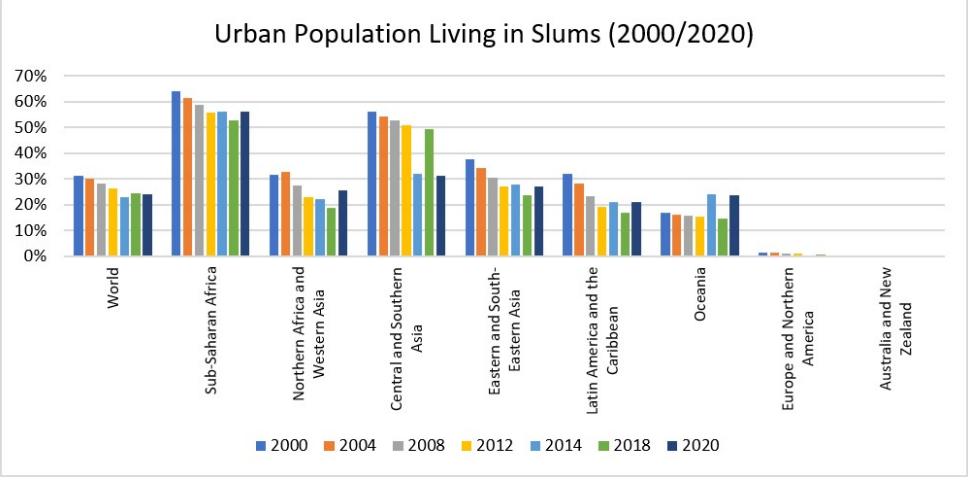

Figure 2. Urban population living in slums (SDG Indicator 11.1.1).

For the sixty year period 1960–2020, over USD$3.78 trillion has been spent on foreign development assistance globally, of which USD$2.8 billion went to Fiji and $48.6 billion to Indonesia (see **Figure 3**) [9].

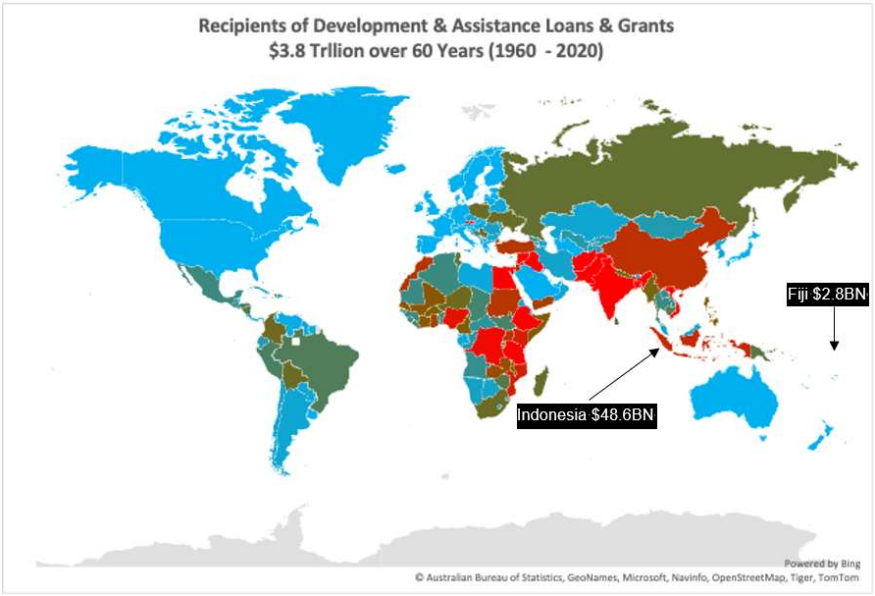

Figure 3. Recipients of $3.8 trillion of aid [9].

Whatever amount of such foreign development assistance funds (net of corruption, currency adjustment, inflation, waste and other indirect costs) were

invested in slum improvement or relocation projects, no standardized metric or methodology holistically tracked or assured positive, durable, contextualized and scalable impacts would be accountable to donor nations, local slumdwellers or the general public [10]. Evaluation of development project performance remains incomplete and highly subjective [11]. Since 2000, the percentage of urban populations living in slums has decreased from 31.2% in 2000 to 24.2% in 2020 [12,13]. With urban populations of 2.8 billion and 4.9 billion in 2000 and 2020, heading towards 6.2 billion in 2050, the decline in urban slum populations left at least one billion slumdwellers at risk [14]. Slumdwellers health are not uniformly measured longitudinally at granular contextual scale on a continual basis [15]. Simultaneously, policymakers are realizing the economic, health, political and social risks that slums increasingly suffer and pose as turning into greater costs, risks and concern for the general population.

Prior research focused on predicting the location and growth of slums, and how the slumdwellers budget their limited resources to survive. No prior research has been found that relates the flows of funds, value and risks transferred amongst the formalized urban geography, the informal settlements ancillary to them and national or international governmental, foundation or other bodies. Urban slums are increasingly being recognized as multi-dimensional, for which multi-dimensional and intersecting policies must be explored and dynamically adjusted to fit local cultures, conditions and governance infrastructures [16].

For the formalized economies of developed nations (such as the thirty-four members of the Organization for Economic Cooperation and Development (**OECD**) [17], sophisticated models describe the inputs and outputs constituting Gross Domestic Product (**GDP**) and household wealth accounts, especially as factors indicative of how banking, insurance and investment activities and taxation rates generate business and household capital accounts [18–20]. With such models, government and foundation interventions and investments can include ongoing incentives for individual businesses or households and their communities to maintain physical improvements that provide services such as via Business Improvement Districts, Water Authority Bonds and Energy Retrofits. The models serve as evidence-based tools for allocating capital, in light of policy goals and their impacts. Such models bring market transparency to the mobility rates of working families, occupations and businesses, and inform how technology, globalization and other trends will shift their options for geographic and demographic growth.

By contrast, financial research in aid of improving conditions in informal settlements has focused on (i) cost-benefit analyses (**CBA**) in support of large-scale infrastructure investments funded by multinational sources for housing, agriculture or water and sanitation; or (ii) studies of how those in poverty survive on meager incomes as the value derived from living in slums accommodations. Notwithstanding CBAs justifying initial investment in infrastructure, funding for maintenance and improvement is often inadequate, which lack of ongoing funding results in abandonment of the physical improvements or renders the improvements incapable of providing the projected benefits over the asset's lifecycle.

This paper proposes a general economic model (**GEM**) for quantifying a series of parallel inflows and outflows for informal settlements to track exchanges of

valuable goods and services, current or future risks and capital. The GEM creates the foundational layer of ground truth to determine who—in addition to the slum dwellers—would have the capacity and willingness to pay for interventions that generate value or reduce risk, thereby producing a revenue stream to amortize costs of installation and maintenance for the intervention. The rest of this paper is organized as follows:

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2. Research literature review

Research is beginning to explain the role of climate, cultural, economic, environmental, infrastructure, governance and social factors in the establishment, growth, movement and transformation of slums. Past research studies have considered:

- The national economic opportunity of moving people out of the poverty of slums [21];
- Slum redevelopment to promote the green economy [22,23];
- How technology changes the drivers of growth in developing economies [24];
- How to map slums and slum growth using geospatial analytics, remote sensing, satellite imagery and machine learning [25–29];
- How adaptation to climate and flood risks affects the economics of slums and urban regions [30,31];
- How children's travel to school improved in upgraded slums [32];
- How men and women move through slums differently [33];

- How upgrading slums shifts perceptions of safety [34];
- How including slumdwellers in upgrading project design and governance decisions affects outcomes [35];
- How holistic design thinking—including the United Nations Sustainable Development Goals (**SDGs**) might improve slum revitalization outcomes [36,37];
- How improving governance at the local level of the village and slum might attract investment and use investment more accountably to improve Quality of Life impacts [38,39]; and
- How sustainable sanitation improves slums [40].

Poverty rates reflect the health or contagion of national and regional economic policymaking and market function, with increases in income levels reducing poverty rates, assuming no changes in regional population [41]. Studies of the economics of poverty are generally disconnected from considering slum revitalization, but provide perspectives on income redistribution, universal basic income (also known as basic income guarantee) and assorted social safety net reallocations and protections (such as public housing allowance, food subsidy and medical care) [42–44].

Empirical observations conclude that conditions of inadequate clean drinking water, sanitation, nutrition, and the expense of medical care and pharmaceuticals lead to poor health and shortened lifespans [45,46], which then reduce incomes in slums, and through moneylending usury, further entrench in poverty once income-earning people [47]. Engineering studies on reducing fire and other vulnerability risks in slums create actionable frameworks, without identifying funding sources or incentives to implement them [48]. Urban planning studies use geospatial analytics to justify dense, modern residential compounds to accommodate low income persons who would otherwise inhabit slums [49].

However, research reveals no comprehensive, widely adopted methodology, akin to computing national GDP, that might serve to quantify and justify paying for improving unhealthy conditions in slums. Given the trillions invested in slum clearance, upgrading and humanitarian response, the lack of such methodological model is surprising, and suggests the disconnections in thinking through how slums intersect other regional and national economic concerns. The closest prototypes for such methodology found come from a 2008 doctoral thesis that explores the economics of space and time in slums [50], and a 2010 thesis conceptualizing a socioeconomic model for slum growth [51]. Clearly, to be meaningful, the SDGs must be more easily translated into local decisions that determine Quality of Life conditions in slums [52].

3. Acknowledging key inspirations

The proposed GEM was inspired by fluid dynamics and similar flow models for biology, engineering, economics, finance, medicine and physics [53]. For engineers, computational fluid dynamics models help design underground gas and petroleum pipes to minimize risks of harms from multiple causes [54]. In biology and medicine, computationally modeling the physics and fluid dynamics of the heart and pulmonary system allows cardiologists to 3D print replacement heart valves that

deliver the proper pressure to the pump's chambers in order to optimize patient blood pressure through a range of sleep-wake-exercise-rest-sleep cycles [55–57]. In parallel, the GEM was inspired by regional and nation-scale macroeconomics, economists and engineers who use input-output flow models to better simulate sustainability and Quality of Life improvement policies that might cause changes in the gross domestic product [58–61]. The GEM reflects the evolution in financial reporting frameworks for accurately and holistically benchmarking the dynamics and integrated operations of individual corporations, and their global supply chains and community impacts [62–64]. As a financial system, the GEM takes a circuit board view of monetary flows such as are being developed for better understanding the risk that a financial institution might incur from, or pose to, destabilizing the global financial system [65]. Extensive comments provided by Emmanuel Picavet, Kathia Martin-Chenut and Andréa Naccache. Finally, and most significantly, the GEM was inspired by conversations and whiteboarding with colleagues at Stanford University, including Dr. Stephen Luby, Stanford University Professor of Medicine and specialist in infectious diseases [66], David Cohen and Jessie Brunner of the Center for Human Rights and International Justice [67,68], and David Grusky of the Center on Poverty and Inequality [69], without whose prompts to innovate, there would be no GEM.

4. The mythology of cost benefit analysis

A standard feature of Quality of Life enhancement and mitigation infrastructure projects in urban regions is to rely on the methodology—some might say, mythology [70]—of cost-benefit analysis (**CBA**) to justify funding the project. Too often, such benefits are not monetized as welfare gains, revenues or as provably avoided costs, but instead reflect the policymaker's or funder's contextually disembodied gestalt and implicit bias or hunch of what matters most to whom where and when, assuming all other variables are constant [71,72]. It is axiomatic that not all valuable things can be quantified, which would be especially true for places like slums that are disconnected from the formal market structures whereby what is valuable is easily quantified [73].

Significant questions bear on the appropriateness, objectivity and methodology of using CBAs in determining slum improvement projects:

- If CBA is the method by which government and foundation program management and funding choices are justified, do CBAs for slums—places largely outside government control and taxation—make sense in explaining how to improve them?
- If CBAs are an extension of the behavioral economics of the "rational man" hypothesis, are slumdwellers' economic decisions on the edge of subsistence properly modeled through the lens of aggregated rational behavior in free choice economic markets [74]?
- For governments and NGOs in the business of operating by the theology of CBA, why are they and the infrastructure projects they fund so often operating in fiscal deficit, since management embracing positive CBA projects would yield annual revenue surpluses, not deficits [75,76]?

The modern form of CBA traces to the U.S. Federal Flood Control Act of 1936, wherein the Army Corps of Engineers was tasked to improve navigable rivers and streams "if the benefits to whomsoever they accrue are in excess of the estimated costs" [77,78]. The ambiguities in this expression of CBA persist more than 80 years later:

- If benefits are quantified solely in the aggregate, how would a benefitted party—other than government—be identified who should be willing to pay for them?
- With benefits aggregated and solely fundable through government, how do public officials explain to the various affected constituencies—for the funded projects and projects seeking funding—why the benefits of a given project were prioritized over other projects' benefits for their beneficiaries?
- When government seeks to recoup costs through tolls, fees, excise taxes or other revenue schemes, how are the projects' benefits traceable to and enjoyed by the ultimate payors of such charges?
- When and in what form would the benefits identified need to be enjoyed in order to be included in the calculation?
- Are costs inclusive of all lifecycle costs (such as maintenance, upgrades, adaptation, environmental, congestion, health and other costs) or solely the costs for physical construction of the project?
- What discount rate should be applied to the costs on the lifecycle for the project and its benefits, given that the funder of the project's costs and the beneficiaries of its benefits borrow at different interest rates?

Given the paucity of consistently available data on slum economic, health and other activities, CBA's shortcomings are magnified as a methodology to justify and arrangement ongoing support for slum improvement projects. This paper explores upgrading the methodology of justifying and financing upgrading Quality of Life in slums.

5. Basic modules for a GEM

As shown in **Figure 4**, the GEM consists of 6 Modules (each a **Module**) in order to accurately contextualize the goods, services and risks flowing within, into and from a slum. Succeeding Sections of this paper explain each Module, and how flows within and amongst them are mapped and quantified. To be most specific, each Section describes a Module by starting with a "How the Module works and why it matters" subsection and moves on to a "How to build the Module" subsection.

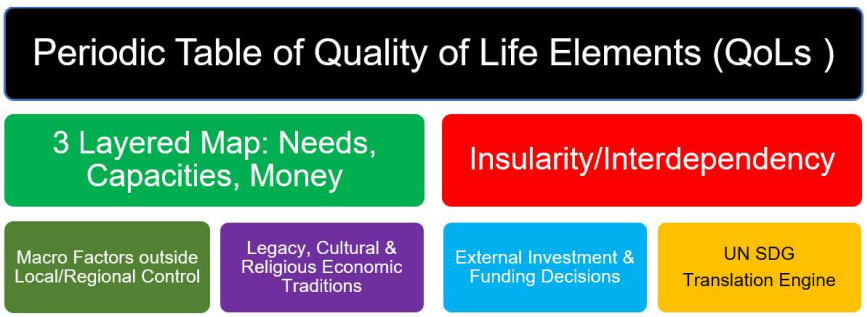

Figure 4. GEM modules.

6. Periodic table of quality of life

6.1. How the module works and why it matters: Periodic table of quality of life

This paper leverages the author's research to create a regional portfolio economics model in the form of a Periodic Table of Quality of Life Elements (**QoLs**), built from the QoL needs that regional budgets (governmental or multinational) prioritize, and the rates of change (progress) in the key performance indicators (**KPIs**) that quantify each QoL as a need. The likelihood that every QoL element's KPI will improve by at least 10% over the decade following the most recent budget creates a credit score called *sustainable resiliency*™. Since QoLs interact endogenously—for instance, education, economic development, health and water and sanitation infrastructure—the KPIs of clusters of QoLs may improve or degrade through the effectiveness of seemingly remote QoLs. For instance, the health and lifespan of a given population might depend on the crime rate, which in turn depends on access to food, housing and jobs (economic development) alongside access to effective healthcare and healthy lifestyle options.

How the KPIs across the entire Periodic Table perform respond to any single QoL element is defined as that QoL's **f-VaR**, functional value at risk, much in the way that portfolio investment theory would see the change to a portfolio's overall yield or safety by trading shares of one company for another [79], or in a bank context, trading one book of loans or financial instruments, for another [80]. With the Periodic Table quantifiable as a dynamic investment portfolio, infrastructure improvements aimed at the f-VaRs for one or a cluster of QoLs can trace their benefits and beneficiaries to the same or other QoLs, enabling an objective and transparent means for discussing how those benefits will be enjoyed in the aggregate, and which funding sources would find it worthwhile to maintain the infrastructure's serviceability. Traditional benefit cost analyses cannot and do not provide such traceability or quantifiable allocation of who has the means and reasons to pay for ongoing maintenance.

In practice, public financial management (in other words, how government finances itself) plays a primary role in leveraging the transparency of quantified impacts computed via the Periodic Table of QoLs. For example, the national or regional government could issue bonds rated or backed by improving its territory's sustainable resiliency score. By proving a bond rating of quantified progress, the interest rate paid to bondholders can reduce and the savings in bond interest can be invested or transferred as payments for the QoL improvements organized and managed at the regional and local levels. Alternatively, the government could adjust property, water and other taxes and fees, based on how the individual business or family creates or mitigates QoLs within its operative domain and control—for multinational companies, such traceable impacts tax policy would be consistent with emerging trends in corporate social responsibility (**CSR**), environmental social governance (**ESG**) and socially-responsible investment (**SRI**) portfolio management practices.

6.2. How to build the module: Periodic table of quality of life

1) Identify a consistent source of three types of national level longitudinal data about QoLs for the region where the slum exists: The operating budget (on annual 12-month cycles), the capital budget (annualized to be on the same 12-month cycle of investment) and the KPIs for each QoL that determined how the operating and capital budgets were authorized or are held accountable, for instance, the crime rate might be the KPI for the QoL of Public Safety budgeted by governments.
2) Obtain such data for a twenty-year period: Ten years before the current budget year, and ten years after.
3) Based on the prior ten-year budgets and the rates of progress in improving each QoL's KPI, compute.
    a) The probability of achieving at least a 10% improvement for all QoLs starting in the current budget year and running through the tenth year thereafter (such probability being the region's *sustainable resiliency*).
    b) The current budgets' cost to improve each QoL's KPI by 10% over the same upcoming ten-year period.
    c) Using machine learning, determine the optimum investment allocation in every QoL currently budgeted so as to reduce the cost and uncertainty of achieving such 10% improvement.
    d) Compute the role that an individual QoL plays (each QoL's *f-VaR*) in reducing or increasing the costs or risk of achieving such 10% improvement across the entire Periodic Table as if the QoLs represented an investment portfolio of stock and bonds.

7. Three-layered map of needs, capacities and money

7.1. How the module works and why it matters: 3-layered map

At their core, government and society at large are in the business of managing a simple set of choices:

- *Defining the needs*: Which need(s) are prioritized?
- *Identifying capacities that address the need*: Which capacities to address the needs are chosen?
- *Finding and managing funding*: How are available monies allocated to the people and institutions representing the capacities to reduce the needs?

In Colonial Times, a monarchy or dominant geopolitical power, made these choices, in a manner that served its purposes, as gatekeeper of the profits to be made, assets to control or political influence to be projected. In the Industrial Age, multinational corporations and NGOs, as delegates of governmental power, made these choices, and enjoyed the profits of gatekeeping progress at regional and local scales, such as by exploiting national resources, corrupt governmental regimes and engineering scarcity through limiting supply in order to foment civil unrest or worse.

Today, needs self-prioritize in response to 24-hour social media directed news cycles, disconnected from each other or larger trends (like climate change), or they appear in the priority of engineered news cycles matched to Congressional Budget

Hearings or foundation grant awards, or they silently serve as justification for institutional agreements moving millions of dollars, Euros or other currency, far above and beyond the reach of local decisionmakers, rewarding corporate shareholders and justifying NGO existence, redundancies and fundraising. Likewise, capacities, the scientific, technological, organizational or other solutions for such needs are identified by the company or NGO who might be expert at identifying and quantifying the need or might be seeking a contract to deliver the capacity they developed, or might have convinced governmental, foundation or corporate investors, lenders or donors to fund their recommended capacity. However, all too often, the local and regional voices of ground truth are missing in choosing (1) which needs in what priority should be addressed to maximize enduring impact; (2) which capacities in the context would satisfy the most needs long-term; and (3) how to wisely use the funds tagged to address specific needs or invest in specific capacities.

In our Digital Age, choosing which needs are addressed in what sequence via what capacities using which funds is amenable to greater continuity, transparency, consensus, local/regional accountability and participation [81]. The UN SDGs are part of an enlightened era of assuring human dignity. Certainly, human dignity includes:

- Having effective accountability and choice over how a myriad of programs steered by outside forces, align to improve QoLs and sustainable resiliency at the local level, and;
- Paying residents of the region being targeted for SDG improvements for their cooperation and ongoing maintenance of, and upgrades to, the equipment, infrastructure and business model that serve as foundational conditions for the initial SDG investment and its CBA. (See discussion of Incentive Fees at Section 16, Section 17 and Section 18.

7.2. How to build the module: 3-layered map

1) Obtain the Google or OpenStreetMap for the region covered by the budgets used for the Periodic Table of QoLs.
2) Using the Periodic Table of QoLs, identify the QoLs having high f-VaRs for the region, and consider this the first version of the *Needs Layer*.
3) Identify strategies used by government, NGO and other actors in the region to track and address the selected QoLs, and consider this the first version of the *Capacities Layer*.
4) Semantically and geographically tag Capacities so that they can be described in a Mediawiki (the software architecture for Wikipedia) format, whereby Capacities used or identified in one geographic region as mitigating a Need, would be discoverable by actors in another region concerned with a similar Need.
5) For the selected QoLs, identify the portion of the budgets from the Periodic Table that fund their activities, and consider this the first version of the *Money Layer*. Geo-tagging the budgets from the Periodic Table of QoLs provides a unique multi-year, cross-functional, intergovernmental, public-private sector

view of funding for the region of concern, and how such funds were intended to be used to address specific QoLs.

6) Using the Google or OpenStreetMap, map the Needs, Capacities and Money Layers so that clicking on a Layer's QoL Element hyperlinks to the budget and other information in the Periodic Table, the calculations of f-VaR and sustainable resiliency, and the optimization for achieving faster progress in improving QoLs' KPIs.
7) Establish a website in local/regional languages and in English for local, provincial, national and international actors to query, suggest data for and engage in debate regarding the 3-Layered Map and the associated Capacities Mediawiki.
8) Invite ideas for using the 3-Layered Map/Mediawiki as dashboard or lens to see and track promised progress, allocation of funds and to discover alternative strategies for more efficient and effective sustainable resiliency.
9) Use the 3-Layered Map to simulate choice optimization in responding to exogenous events like climate change or natural disaster.

8. Insularity/interdependency

8.1. How the module works and why it matters: Insularity/interdependency

The rates of flows for QoLs, how they worsen or improve, depend, in part, on the insularity or interdependency of a slum geographically, politically, socially and especially, economically. A slum that provides labor to the urban or rural formalized economy for farming, food preparation, housekeeping, landscaping, day labor construction, transportation or other services, transfers economic, health, information and other flows more effectively—fluidly—than a slum that is physically, socially and economically isolated. Such insularity/interdependency moderates or amplifies the velocity of inter-community flows. Insularity/interdependency introduces a factor into the GEM akin to the multiplier effect for the economics of consumer demand or money supply growth [82], or the multiplier effect of pollutants originating or exacerbated by slums and the energy use by urban office and residential buildings to try to filter them from indoor air conditioning [83].

8.2. How to build the module: Insularity/interdependency

For the twenty-year period used to build the Periodic Table of QoLs,

1) Using aggregated metadata publicly available for research from Facebook or similar social media platform, analyze the affinity group fractals for the region of concern—for years prior to widespread access to or use of social media, use government or other surveys.
2) Predict the insularity/cohesion of:
    a) Self-identified demographic groups within the region of concern;
    b) Such identified demographic groups with groups located (or with IP addresses) outside the region.

3) Within the bounds of privacy protection laws and best practices (such as GDPR), detect semantic words used by in-region/outside of region demographic groups that signal concern for or awareness of QoLs within the region.
4) Compute the probability that QoLs that worsen within the region will be discussed identified demographic groups:
   a) Within the region;
   b) Outside the region.
5) Use the calculated probabilities to score the insularity or awareness of interdependency for identified demographic groups.
6) Use the probability scores as sentiment for how voluntary or political investments in the slum might be justified as worthwhile.

9. Legacy legal, cultural and religious economic traditions

9.1. How the module works and why it matters: Legacy economic traditions

Slums exist across a variety of geographies, where traditions of culture, religion and legacy governmental role and legally enforceable rights and subsidies have determined, in non-obvious ways, the rules by which QoLs will be identified and improved, for whom, at what rate. In the U.S., despite statutory assurance of equal rights to employment, education and housing, minorities and marginalized communities still remain behind in achieving adequate levels of QoL elements (such as lifespan, career earnings or homeownership equity).

Frequently slums result from natural or unintended consequences—or broken promises—of government upheavals, housing programs and budget deficits or misuse [84].

Stepping back from the name and inherited theology of a religious belief system or other philosophical tradition, one might first ask “Where did these beliefs and traditions come from, and why are they preserved, adapted and implemented in their current form?” of greatest moment in constructing the GEM is to respect traditions and beliefs that represent behavioral economic practices, ideologies and truths.

Religion has served as a human core for intergenerational memory of a set of economic and social rules, often encoded in parable as the lesson learned. As a reminder and living proof of what matters to its congregants, religion plays a primary role in QoL access or denial, formally or informally.

It is all too true—and sad—that sectarian extremists in the developed and developing world misquote, decontextualize and misappropriate religious teachings, in order to self-justify denying basic safety and human rights (QoLs) to those labeled “non-believers”. Likewise, true is that religious leaders and institutions have been slow to monitor and upgrade their practices to comport with modern secular legal and universal moral edicts.

Notwithstanding such transgressions, religious affinity and observance can be a rational and social justice tool in reaching consensus and choice concerning needs, capacities and money. The leadership of Traditionally Black Churches in revitalizing their neighborhoods, small businesses and housing stock is just one example. The

emergency response of the American Jewish World Service and the Catholic Relief Services are further positive examples of putting beliefs into practice in service of those in need. From this perspective, religion can translate the clinically correct objective truths reflected in the Periodic Table and the choices in the Three-Layered Map into more subjectively motivational and congruent calls for its clergy and congregants to act ethically, in pursuit of economic, environmental and social equity.

In deploying the investment capital and savings of its congregants, universities and institutions, in utilizing, renovating and repurposing its buildings and real property holdings and farmland, religions and their lay leadership have numerous options for improving QoLs, even by having the basic curiosity to ask, "What impacts are our choices having on others' rights to choose ways to improve their QoLs"?

9.2. How to build the module: Legacy economic traditions

For the twenty-year period used to build the Periodic Table of QoLs,

1) Obtain an objective assay of ethnic, racial, religious and cultural demographies living or working in, or governing, the region of concern.
2) Obtain in digital form the sacred, historical or biographical textual writings that authenticate the lifestyle and journeys of members of each tradition.
3) Using artificial intelligence/machine learning (**AI/ML**), mine the texts for economic words and principles of universal or group significance, such as land tenure and conveyancing rights, rights to wages for labor expended, lending or borrowing (on interest), taking of assets on pledge as collateral, debtor's and creditor's rights, partnership formation and business partnership operational rules, resource extraction and use, agricultural, food purity and ritual health requirements, investment norms, and tithing or other rules for alleviating the plight of the poor, the unemployed and their families marginalized by economic adversity (collectively, each group's Economic Traditions).
4) Correlate the Economic Traditions with the QoLs directly or indirectly impacted or conducted as a result of them, so as develop coefficients of sensitivity for the major Economic Traditions of each group.
5) Use the QoL mappings of the Economic Traditions to engage in human rights, regional justice and multi-lateral conflict resolution dialogues where the over-arching goal is to granularly steward Capacities to meet shared Needs, while simultaneously reducing fraud, waste, delay, corruption and extortion burdens on the local and regional economy.

10. Macro factors outside local/regional control

10.1. How the module works and why it matters: Macro factors outside of local control

Climate change, drought, flood, hurricane, earthquake, wildfires, insect-borne crop loss (**Natural Disaster Events**). Globalization, recession, expansion, inflation, devaluation **(Economic Adjustment Events**). Artificial intelligence, remote sensing, robotics, blockchain, space mining (**Technology Adjustment Events**). Civil or

regional unrest, warfare, regime change, governmental shutdown, rationing, forced migration or curfew (**Political Disruption Events**). These and other trends (collectively, **Major Adjustment Events**) will affect the futures of urban, rural and informal settlements. Their effects will be unequal, benefitting or threatening QoLs unevenly: The same remote sensing processed and tagged by artificial intelligence to improve crop yields might permit more vigilant segregation or reduce the wages of entry-level positions to manually scan and tag spatial imagery to identify features like buildings, roads and trees. Such technology and other factors are never benign and will impact slums in ways that have little accountability, and over which they have no control except in choosing to name, respond and adapt to the change.

Climate change and to an extent globalization (through CSR, ESG, SRI performance ratings) are special opportunities for slums that proactively see and mitigate their QoL dependencies (internal to the slum) and interdependencies (external). A slum flooded by hurricane or monsoon might choose to leverage the post-disaster international aid monies to negotiate land tenure rights in a more resilient region, on higher ground or by building houses, schools and other structures better able to respond to and survive natural disaster.

10.2. How to build the module: Macro factors outside of local control

For the twenty-year period used to build the Periodic Table of QoLs,

1) Obtain the national, and ideally regional, econometric data for the region of concern;
2) Obtain the dates and extents of major changes in the econometric data, including the industry sectors affected thereby represented by (i) the QoLs; and (ii) the taxes and other revenues funding government budgets;
3) Obtain the dates for Major Adjustment Events, to the extent susceptible of ascertainable date or date range;
4) Using AI/ML, find statistically significant relationships amongst the major changes in econometric data and the Major Adjustment Events.

11. External investment and funding decisions

11.1. How the module works and why it matters: External investment and funding decisions

Intergovernmental transfers from multinational, national or regional sources. Foundation grants. Philanthropy. Corporate investments. Social impact bonds. All represent non-indigenous capital flows into the slum or the governmental unit to which it is ancillary. Such external flows routinely are allocated on an annual or short-term basis, in response to a Natural Disaster Event or emergency condition or are otherwise episodic rather than perennial in nature [85–87]. Often, the justifications or randomness creating such external funding and its programmatic uses rest on decisions made without local input, and rarely explained to be accountable to local rights of self-determination. Once such external funds disappear or their reauthorization is put in doubt, the slum must determine whether to fund, and

how to fund, maintenance or completion of homes, farms, road, water and sanitation infrastructure, healthcare, schools and other assets used to assure QoL.

Due to international banking anti-money laundering (**AML**), counter-terrorist funding (**CTF**) and "know-your-customer" (**KYC**) regulations, such as from the Bank for International Settlements (**BIS**) [88] and Financial Action Task Force (**FATF**) [89], remittances, supply chain payments, loans and investments are routinely "tagged" for the identity of the parties to the transactions, their country of origin and the geographic region involved. Government and corporate compliance and investor, bank and insurer concerns are further tagging flows so CSR, ESG and SRI programs can identify and mitigate impacts directly or indirectly attributable to financial activity. Foundations in the U.S. and Europe annually report their grant funding to NGOs active in different countries across numerous QoLs. Government assistance and foreign aid flows are reported within project acquisition and procurement databases. Many of such digital databases are publicly available online or via Freedom of Information requests.

At present, much of this data is in disaggregated and non-interoperable form. With globalization of corporate, finance and insurance markets, such data will become interoperable in standard format to reduce compliance costs and improve the value of insights derived from readily comparable data. The upshot is that data on investment and funding decisions that affect QoLs in slums and their regions will become readily available. The GEM positions projects aimed at improving slums to be ready users of such data.

11.2. How to build the module: External investment and funding decisions

For the twenty-year period used to build the Periodic Table of QoLs,

1) Obtain from the nation's central bank, treasury, budget management office or other domestic or multinational finance source, a list of the sovereign debt issued, refinanced or otherwise arranged and the repayment terms therefor (annual debt service, fees, etc.).
2) Obtain from the region's treasury, budget management office or other domestic or multinational finance source, a list of the sovereign debt issued, refinanced or otherwise arranged and the repayment terms therefor (annual debt service, fees, etc.).
3) Obtain from investment bank funding announcements, league tables or other financial industry data sources, the government debt and corporate debt issued and refinanced, where the borrower, the collateral or the project financed is located or primarily for the benefit of operations in the nation or region of concern, and to the extent publicly discoverable, the repayment terms therefor (annual debt service, fees, etc.).
4) Obtain from government and foundation grant data sources, the grants issued in response to, or in anticipation of, Major Adjustment Events, including debt forgiven or postponed.
5) Through interpolation, subject to reasonable and defined assumptions, consolidate the data from Steps 1, 2, 3 and 4 to estimate the net inflows and

outflows of capital, and the accrued burden of debt service and principal repayments therefor.

12. Sustainable development goals translation engine

12.1. Using the SDGs to bring global resources to local QoL needs

So far, the UN's SDG's do not connect the economies of the urban developed and slum districts, nor to the national, regional and local budgets by which to fund incentives, investments and ongoing maintenance of, and reinvestment in, slum SDG improvement, nor UN Sendai Framework disaster resilience measures [90].

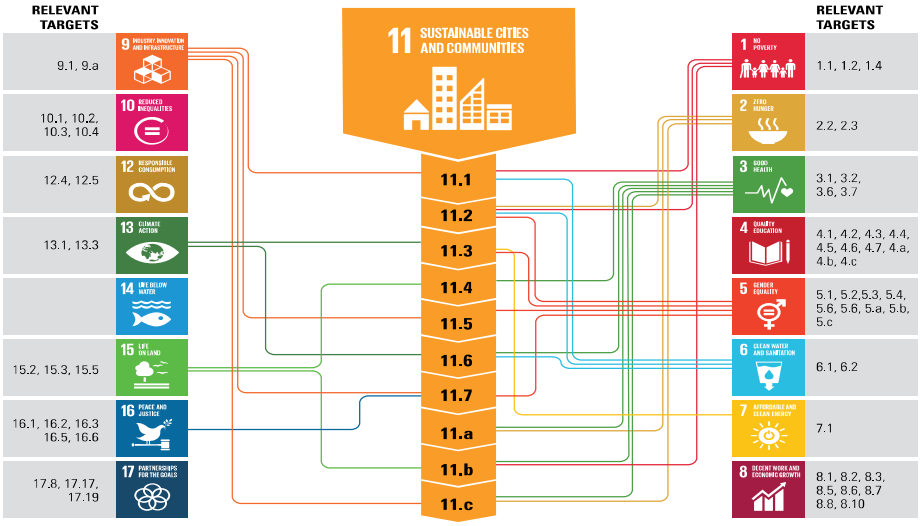

Figure 5. Interlinkages between SDG Goal 11 "Sustainable Cities" and other SDGs.

Figure 6. Linkages between SDGs and urban economic output.

The UN SDGs provide a *nomenclature* for desirable sustainable development *outcomes* and their *interdependencies*, (**Figure 5**) [91]. However, they offer no *methodology* to *quantify* their *value* in situ for purposes of *funding* the production and use of each SDG on a standalone basis, as a cluster or as an integrated portfolio of outcomes [92].

The UN has suggested that SDGs could be mapped to urban economic outputs (**Figure 6**) [91].

The UN has suggested that the SDGs could map to its Sendai Framework for disaster risk reduction (**Figure 7**) [91–93]. National urban policies (**NUPs**) provide additional roadmaps to identify QoL and SDG tags on local sustainability and resilience investments and projects [94].

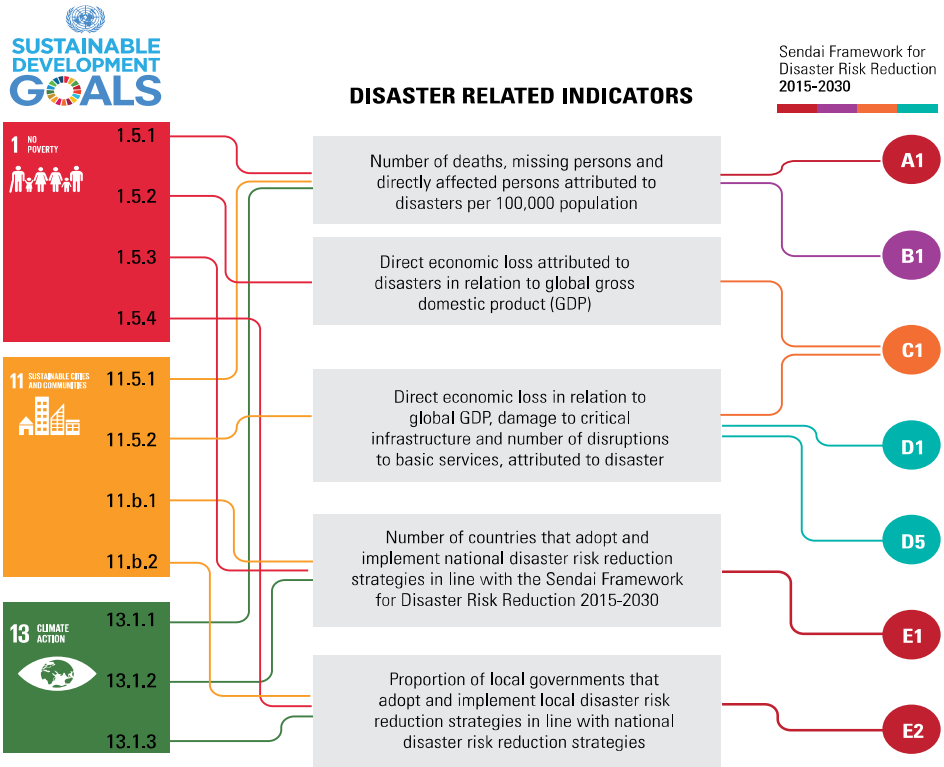

Figure 7. Interlinkages between the Sendai framework and SDGs.

In short, SDGs speak the language of international policymaking not local budgeting and political decision-making [95–97].

QoLs expressed in locally measured KPIs and allocated budgets, once visualized into the Periodic Table of QoLs as a portfolio of cash and investment flows, as a means to align needs, capacities and money in the Three-Layered Map, and as a Module in the GEM, become a foundation for matching local governance and budget process languages with the *outcomes* identified as SDGs.

12.2. How the module works and why it matters: SDG translation engine

As must be acknowledged (Section 12.1), the UN SDGs constitute a major effort to define progress and resilience in urban and slum development. With all of their shortcomings, the SDGs represent a global effort that is responsible for assessing local QoLs and allocating funds to improve them. What is missing in the

SDGs as developed and implemented to date is a way to connect them to the national, regional and local budgets of governments responsible for slums and the people living there. With a translation engine, the activities and budgets untagged to their SDG significance could be tagged in order to better attract and maintain funder interest in SDG impact investment and philanthropy practices. Taken from the other direction, SDG tagging of fiscally identified QoLs would permit lenders, investors and donors to see a wider arc of how their funds perform in relation to other SDG and non-SDG factors. While the SDG translation engine is not a necessary component of the GEM for slums, building it will likely improve global understanding of how cities and their slum neighborhoods are interdependent.

12.3. How to build the module: SDG translation engine

1) Obtain the SDG Taxonomy in its most granular and recent form [98].
2) Obtain the NUP for the region(s) described in the Periodic Table of QoLs [94].
3) Identify for the 20-year period covered by the Periodic Table of QoLs (see Section 6.2):
    a) Global donor nation, development bank, foundation or corporate funds tagged by SDG-justifications or desired outcomes;
    b) The government or private sector recipient of such funds;
    c) The government or private sector program or business enterprise supported by such funds;
    d) The outcomes claimed to be achieved by such funding upon its renewal or cessation;
    e) The location(s) and boundary of activities so funded.
4) Associate the Flows with the sources and SDG tags in item #3 above.
5) Use the KPIs for the QoLs tagged in the Flows to quantitatively map a concordance, connecting:
    a) National, regional and local governments budgets that use a given KPI to guide their activities or prove their success, and;
    b) SDGs that use the same or a similar KPI to guide their activities or prove their success.
6) Use the concordance from item #5 to quantify and reprioritize which QoLs are:
    a) Included in the SDGs and funded in national, regional and local government budgets;
    b) Excluded from the SDGs and funded in national, regional and local government budgets;
    c) Excluded from the SDG and not funded by national, regional or local government budgets.

13. Building on SDG commitments: Fiji and Indonesia

13.1. Contextualizing national SDG commitments

The member states adopting SDGs do so for a wide variety of reasons, beyond environmental, humanitarian and social. Constitutional rights, democratic reform, dependence on foreign aid and development finance. Whatever the reasons for

national SDG commitment, fiscal budgets and sovereign debt borrowing capacity constrain which SDGs the nation will prioritize and achieve, to what extent, by the SDG target date of 2030. To better appreciate the national context for SDGs and how that context might be leveraged to implement the GEM, consider the cases of Fiji and Indonesia, as shown in **Table 1**, and discussed in Section 13.2 and Section 13.3.

Table 1. Statistical comparison of Fiji and Indonesia.

	Fiji	**Indonesia**	**Source**
Population (Millions)	0.944	277.3	[99]
Human Development Index (HDI) - Country Rank	0.743–93rd	0.718–107th	[100]
Life Expectancy (years)	67.4	71.5	[100]
Landmass (square kilometers)	18,274	1,811,569	[99]
Independent Statehood	1970 (52 years)	1949 (73 years)	[99]
Poverty Rate: living Below national poverty line	24.1%	9.8%	[101]
Inequality Index (GINI)	36.7	39.0	[100]
Corruption Perceptions Index	55–45th	38–96th	[102]
GDP (USD$ Billion)	$4.6	$1186.1	[103]
GDP per Capita	$5086.0	$4291.8	[104]
Government Bond Credit Rating	S&P B+ stable	S&P BBB stable	[105,106]
Government 10-Year Bond Yield	4.25%	7.365%	[107,108]

Compared to Fiji, Indonesia's population is 292 times greater, its landmass is 98 times more, its economy (GDP) is 256 times larger. Yet Indonesia's GDP per capita is 16% less, its corruption is perceived as 69% more and it pays 75% more for its long term (10 year) government debt.

13.2. Fiji's commitments to SDG Goals

Fiji's national government has ambitious plans and historical commitments for addressing the SDGs, from climate change to financial inclusion, and beyond [109]. The SDG Goals add accountability, transparency and KPI targets that correspond to human rights guaranteed by Chapter 2 of Fiji's Constitution, including rights for Equality and Freedom from Discrimination (§26), Children's Basic Needs (§41), Health (§38), Education (§31), Healthy Environment (§40), Housing and Sanitation (§35), Adequate Food and Water (§36), Access Government Information (§25, Tenancies and Interests in Land (§29), Freedom from Arbitrary Evictions (§39), Work and Receive a Just Minimum Wage (§33), Access to Transportation (§34), Respect for Persons with Disabilities (§42) and others [110].

Fiji's national government and its budget are primarily responsible for organizing and funding the SDGs and related constitutional and governmental rights, albeit that local governmental councils exist, receive rents and dispense a minor share (1.5%) of government-funds [111]. While Fiji's Constitution guarantees various SDG-analogous rights [112], certain Constitutional guarantees are limited to the national government's available resources [110]. Stated differently, the politics of government budgeting limits whether, when, to what degree and for how long

certain guaranteed Constitutional rights will be realized, as shown in **Table 2**, where unconditional rights are shaded green, and conditional rights are shaded red.

Table 2. Selected Constitutional rights in Fiji and their corresponding SDG Goals.

Fiji Constitutional Right	Fiji Constitution Chapter 2 Section	Is Fiji Constitutional Right Limited to Available Resources?	SDG Analogous Goal Number
Access Government Information	§25	No—Unlimited	Peace, Justice & Strong Institutions (#16)
Equality and Freedom from Discrimination	§26	No—Unlimited	Reduced inequalities (#10)
Respect for Tenancies and Interests in Land	§29	No—Unlimited	Peace, Justice & Strong Institutions (#16)
Education	§31	Yes—Limited	Quality Education (#4)
Economic Participation	§32	Yes—Limited	Decent Work & Economic Growth (#8)
Work and Receive a Just Minimum Wage	§33	Yes—Limited	Decent Work & Economic Growth (#8)
Access to Transportation	§34	Yes—Limited	Sustainable Cities & Communities (#11)
Housing and Sanitation	§35	Yes—Limited	End Poverty (#1) Sustainable Cities & Communities (#11)
Adequate Food and Water	§36	Yes—Limited	Zero Hunger (#2) Clean Water & Sanitation (#6)
Health	§38	Yes—Limited	Good Health & Wellbeing (#3)
Freedom from Arbitrary Evictions	§39	No—Unlimited	End Poverty (#1) Sustainable Cities & Communities (#11)
Healthy Environment	§40	No—Unlimited	Sustainable Cities & Communities (#11)
Children's Basic Needs	§41	No—Unlimited	Quality Education (#4)
Respect for Persons with Disabilities	§42	No—Unlimited	Decent Work & Inclusive Economic Growth (#8) Sustainable Cities & Communities (#11)

Given the intervening urgencies of any particular fiscal budget year (such as 2020's COVID-19 Pandemic Response discussed in Section 19) and the inherently political nature of government budgets to deprioritize under-represented peoples and regions (such as those living in the slums), SDGs that depend on "available resources" must seek separate non-governmental funding, that may ebb and flow inconsistently. In its 2019–2020 Budget Estimates, Fiji relied in part on foreign government or NGO funding from UNICEF for its Child Protection Program and Water, Sanitation & Hygiene Program, the UN Development Program (UNDP) and the New Zealand Agency for International Development for Access to Justice, the EU for its Sustainable Rural Livelihood and Technical Support for Economic Reforms, the World Bank for Reducing Emission from Deforestation and Sustainable Energy Financing, India for Micro and Small Business Grants, among other external funders [113]. Fiji's 2022–2023 Budget Estimate project that international donor aid for such activities will be significantly cut in 2023–2025 [114,115].

In order to assure the Constitutional rights of all Fijians are fully and reliably resourced, the affected communities and their government must create innovative financial mechanisms that put the power of staying funded in the hands of all citizens.

13.3. Indonesia's commitments to SDG goals

For Indonesia, the SDGs serve as a cornerstone for the country's path towards participative democracy. Indonesia's Constitution has evolved to assure its citizens numerous rights such as basic human rights that assure Quality of Life (Section 10), rights to receive education (Section 13), participate in the benefits of exploiting the country's natural resources (Article 33), support for social welfare programs to alleviate poverty and inequality (Article 34), democratic elections (Article 22E), accountable budgeting (Articles 23 and 23E), respect for indigenous peoples' rights (Article 26, assurance of equal treatment under the law (Article 27) and others [116–118].

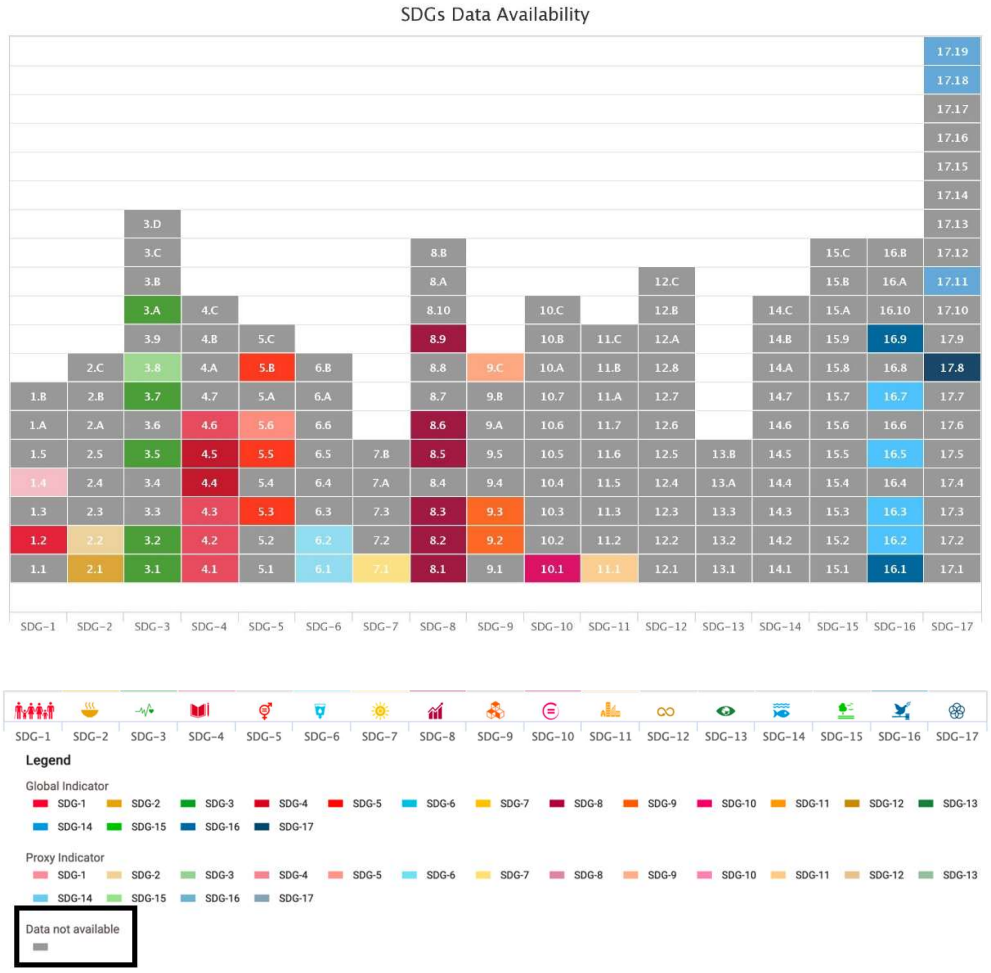

Figure 8. Indonesia's SDG data (missing data shown in grey).

President Joko Widodo campaigned on a platform of accountable, effective and participative government to deliver the Constitutionally guaranteed rights [119]. By Presidential Decree 59/2017, a detailed, multi-stakeholder National Action Plan was developed to achieve the SDGs, coordinated by the National Development Planning Agency [120,121]. Modern online map and statistical dashboards show information available for several SDGs and track the nation's progress in closing gaps for such SDGs [122]. As **Figure 8** shows as of June 2020, Indonesia lacks direct data or

proxies for accurate data tracking most SDGs consistently across the archipelago nation's 17,504 islands [123,124].

Between 2020 and 2030, Indonesia's SDG National Action Plan depends disproportionately on non-governmental financing to fund short- and long-term achievement of its SDGs [125]. Modeling for moderate vs. high investments in, and rates for achieving, its SDGs, Indonesia will have to augment its business-as-usual investments by billions of US$, as shown in **Figure 9** [125]. As a majority Muslim nation (87%), religious traditions of charitable giving and tithing (*Zedakah* and *Zakat)* for the poor and social welfare could provide significant funding for the SDGs [126–128].

Figure 9. Sources for funding to achieve Indonesia's SDG plans 2020–2030.

For reasons described in Section 19.3 the COVID-19 Pandemic reallocated and disrupted governmental and non-governmental funding for Indonesia's SDGs. One of the SDG National Action Plan's key funding strategies depends on innovations in tracking and incentivizing domestic economic, social and environmental impacts to self-mitigate gaps in the SDGs [125].

Indonesia's Ministry of National Development Planning (BAPPENES) and the country's Ministry of Finance are primarily responsible for the process of implementing an Integrated National Financing Framework for the SDGs [129]. As of June 2022, the framework and its implementation timetable have yet to be established and implemented [130]. Indonesia's progress reports on implementation of its SDG policies and priorities do not appear to leverage the village Finance Information System (Siskeudes) and its capacities to enable hyper-localization of SDG goalsetting and realization [131], which leverageable opportunities are discussed in Section 20.4, Section 20.5 and Section 20.6 below.

Indonesia's national and regional governments depend in part on a portfolio of tax and royalties from mining and other companies operating there. 25% of the net profits of mining are paid in taxes to the national government, which mining revenues funded 7.4% of national budget in 2018 [132,133]. However, there is limited transparency as to the national government's Constitutionally guaranteed

(Article 18A) fiduciary performance in sharing such revenues with regional and local governments to offset the SDG impacts of mining activities there [116]. Regular and extraordinary commodity price shocks, such as the collapse of oil prices accompanying (i) the 2020 Q1 reduction in demand for travel and manufacturing; (ii) the COVID-19 Pandemic; and (iii) the great powers competition between Russia and Saudi Arabia to control global oil output and pricing, directly reduce government revenues and their allocation to local Indonesian SDG efforts.

13.4. Takeaways from SDG implementations in Fiji and Indonesia

Examining national commitments to and funding of the SDG implementations in Fiji and Indonesia suggests several working assumptions:

1) As a subset of measurable QoLs, the SDGs align well with, and make accountable, the democratic principles and human, environmental and legal rights guaranteed in national Constitutions.
2) However, in government budgets, SDGs take a secondary or tertiary funding priority, so that actually achieving selected SDGs depends largely on (i) unreliable non-governmental funding; and (ii) the subset of QoL data that governments produce to attract such funding.
3) Progress will lag in proportion to the lack of innovation and consistency of funding SDGs.
4) Once QoL impacts in the informal economy are quantifiable and can be shown to de-risk activities and investments in the formal economy, QoLs will be measured, self-funding and attract ongoing mitigation investments from national governments.

14. Putting the GEM together

Like the engineering of a mechanical watch or an electronic circuit board, the GEM's Modules interweave once filled with data, assembled and connected properly. In order to track flows within, into and out of the slum, two GEMs need to be assembled: One for the slum, and a second for the formalized economy of the urban or rural region in which it sits or to which it is ancillary.

By design, the GEM for the urban or rural region of which the slum is a part will be easier to assemble, since ordinarily national and regional government budgeting generates, relies on or responds to much of the data used in the GEM.

While consistent data about the specific slum may be scarce today, future years analysis will benefit from advances in the interoperability standards for (i) global corporations to report on their supply chains, and environmental and social impacts; (ii) government finance reporting to anticipate QoL insufficiencies as part of bondholders' and credit rating agency analysis of political risk, sustainability and resilience; and (iii) satellite imagery, remote sensing, Internet of Things (**IoT**) devices and other commercially cost effective technologies and accompanying datasets to monitor local and regional assets, populations and risks.

15. Tracking QoL value and risk flows in and through slums

15.1. How the module works and why it matters: Tracking QoL value and risk flows

With the slum and major regional GEMs assembled, relevant flows (**Flows**) of QoLs, their interdependencies, funding and variables impacting them and that they impact can now be tracked.

First, consider why tracking Flows matters.

Health threat scenarios are readily understandable because they acutely jump socioeconomic and geographic boundaries:

- A hospital worker or hospital supply delivery worker lives in the slum and commutes to work in the hospital on bus or other shared ride transportation two hours each day. If this person contracts a communicable disease, this person and everything they touch, including the air they breathe, the handrails on the transport vehicle and the glassware they use for drinking liquids can become a vector for spreading the disease.
- Take a non-human version of the health scenario, this time featuring animals, birds, rodents and insects. Such non-human vectors can be more effective and persistent at spreading disease but cannot be quarantined or sequestered from moving between the slum where they feed and reproduce, and the urban or rural economic centers of the region.
- A third health scenario involves the increasingly frequent and more severe Natural Disaster Events affecting overpopulated neighborhoods in highly vulnerable coastal, seismic or other locations. When disaster strikes, shortages of medical treatment, pharmaceuticals, food, shelter and wage-paying employment cause slumdwellers to swarm into suburban and urban neighborhoods, bringing health and other QoL issues in tow.

Self-interest would drive attention of urban dwellers to focus on each health scenario. But what Flows and what incentives would drive attention of slumdwellers, of limited financial means, to mitigate QoLs of greatest threat to themselves initially, and to urban dwellers or workers derivatively?

Without (i) a common digital taxonomy defining Flows for purposes of obtaining an integrated reporting framework; or (ii) an AI/ML service that learns how to discover, normalize and compare the key data, assembling the Flows will be possible, though cumbersome, with numerous manual transformations and interpolations of datasets not normally used together. Tracking Flows will become easier with online access to increasing semantically-tagged digital data from international treaty and agreement accountability and transparency commitments (such as the Paris Agreement on Climate Change) [134–137], government budget and operational sources, supply chains, corporate financial reporting (such as shared in XBRL: eXtensible Business Reporting Language) [138–140], Internet of Things (**IoT**) sensor sources, airborne drone and space-based remote sensing and normalized historical data.

15.2. How to build the module: Tracking QoL value and risk flows

1) Review the history of fluid dynamics modeling [141].
2) Review how Computational Fluid Dynamics (**CFD**) has been applied to multi-dimensional modeling of natural, physical and other phenomena, in order to find analogies for applying CFD to model financial phenomena [142–144].
3) Review relevant commercial and open source CFD software for engineering, engineering, financial, geophysical, mathematical, medical and other models of fluid dynamics in order to determine the most relevant and adaptive software to use in building this Module [145].
4) With the large dataset of Flows assembled for the Periodic Table and other Modules (use CFD analytical tools to map Flows, their counterparties inside and outside slums, their interactions, interdependencies and other effects).

16. Computing incentive payments to slumdwellers for positive impacts

16.1. How the module works and why it matters: Paying slumdwellers for positive impacts

Government in developing countries tends to misallocate foreign aid and other external funding and internal tax and other revenues to programs and projects that benefit higher-income households and their economic and political interests [146]. With global wealth concentrated in few hands, government tax, fiscal and global development aid policies have proven long on defining goals for marginalized communities—like the SDGs—and short on providing adequate and reliable funding to achieve them [147]. Government and foundation funding delays and narrow scope filters frustrate continuity of efficient, effective and innovative deployment of available funds. Slumdwellers should have a right to be paid for playing their part in achieving SDGs and the broader QoLs, especially when the improvements raise government bond ratings, thereby reducing government budgets for the QoLs and associated sovereign debt outstanding, government debt service, inflation and political instability. Slumdwellers' QoL contributions would validate emerging sustainable finance bond programs, such as seek to promote SDGs [148].

Financial inclusion empowers marginalized and vulnerable peoples—women, girls, boys, men, LGBTQ, the disabled, the elderly, ethnic minorities, the poor—to safely participate in generating real economy goods and services, valued based on information available within and outside the slums [149–151]. Mobile phone deployment has revolutionized slumdweller access to direct financial services [152], via personal mobile wallets to securely receive, send and store payments without money transfer agents or the time and risk of transacting in cash [153,154].

Consistent with respect for data protection and privacy [155–159], data provided by mobile phones through mobile carriers and online services can generate new knowledge about, and ways to monitor, QoLs and Flows in the slums. Based on the slumdweller's geolocation in the slum or movements through the slum, existing location-aware mobile phones can record rights to incentives for QoL improvements.

Incentives for improving QoLs and the Flows generating them can be paid to slumdwellers in multiple parallel forms: Monetary (local fiat currency or cryptocurrency, such as Bitcoin or Ether), credits redeemable for commercial goods and services (such as rights to cellphone minutes or data use) or guaranteed arrangements for obtaining land tenure or other valuable property rights. Incentive fees paid in cash, monthly cellular data plans or tokenization via cryptocurrency directly into the hands of slum residents [160], Nonmonetary transfers, such as earned rights to assured land tenure in the nature of installment land contracts to better housing units developing inside or outside the slum and providing slumdwellers with appropriate habitability and conscionability protections, also could be used as incentives [161–163]. Legal technologies provide the means to automate awarding, ledgering and operating the award of land grant or similar legally enforceable rights, via so-called "smart contracts" recorded on immutable blockchains [164,165]. For urban centers and their associated slums in developing countries that adopt blockchain-based real property land registries as a component of upgrading administration of national urban policies (NUPs), such installment land contracts easily could be recorded and enforced [166–168].

16.2. How to build the module: Paying slumdwellers for positive impacts

1) Develop, co-develop or license secure and privacy protective a financial technology (**fintech**) application platform for slumdwellers' mobile phones to manage their personal and small business finances, apply for loans and insurance on reasonable terms, and to track their financial health and wellness.
2) Using data on the Flows and their impacts on QoLs' f-VaRs, identify moments and tasks during the day, week or annual crop, school or other season when the slumdweller can play a compensable role in assuring QoLs, such as in disposing on refuse, cleaning WASH infrastructure filters or obtaining and delivering excess quality food.
3) Send a text alert to the slumdweller of offers to earn compensation for such role, and reward slumdwellers who respond by completing the task they assume.
4) Rank slumdwellers by their reliability in completing assumed tasks.
5) Produce a map of the slum showing how performance of assumed tasks improved QoLs.
6) Use the map to show "popular" and "unpopular" tasks in order to explain how f-VaR pricing of assumed tasks rewards critical tasks more.

17. Determining the source(s) for incentive payments to slumdwellers for positive impacts

17.1. How the module works and why it matters: Finding sources for incentive payments to slumdwellers

Proving that savings (**Slum Benefits**) in producing, assuring or de-risking QoLs can be achieved through cooperative activities of slumdwellers does not automatically manifest enthusiasm in the government, insurers, corporations or

others in the formalized economy (**Mainstream Beneficiaries**) to pay slumdwellers for their cooperation in producing Slum Benefits.

Identifying Mainstream Beneficiaries and their business models and modes of financing their operations (**Mainstream Beneficiaries' Financings**) permit clinically reviewing how the Flows intersect their costs and risk exposures from unimproved QoLs, their government and corporate credit ratings, and the derivative stock and bond market value of narrowing the fluctuations in improved sustainable resiliency. The Three-Layered Map showing where funding is already tagged to address a QoL need, and which public or private sector organization controls such funding and is responsible for improving the QoL's KPI can self—identify funding sources for incentive fees to slumdwellers. (See Section 7) For government officials competing to form coalitions in the rites of reelection, assured QoLs may reduce pressures to raise taxes, to ignore marginalized populations or disenfranchise voters inside, or concerned with conditions in, the slums.

Mainstream Beneficiaries routinely enter into public-private partnerships or other legally binding arrangements to de-risk operations, obtain goods and services at a discount or reduce opposition political forces, especially where prior QoL activities, risks or inaction have created negative media attention voter backlash or bank or global finance penalty. The prophylactic nature of the GEM and its potential for multi-year arrangements that use the slums as an engine for Slum Benefits is an intriguing option for forward-looking government officials and corporate managers.

Through philanthropy, impact investing and donor-advised funds, large pools of capital have self-identified as desiring to invest in, lend to or make grants to macro—prudential programs for change such as the SDGs and the GEM attract.

17.2. How to build the module: Finding sources for incentive payments to slumdwellers

1) Start by identifying an initial cohort of Mainstream Beneficiaries that
    a) Are included in the Periodic Table of QoLs and the Three-Layered Map;
    b) Are recipients or gatekeepers of the money catalogued in the Three-Layered Map.
2) For the relevant Mainstream Beneficiaries' Financings, review their
    a) Prospectuses, offering statements or bond indentures;
    b) Credit ratings and the credit rating agencies' and bond analysts' areas of concern in assigning the credit rating;
    c) Financings that specifically target QoLs or SDGs.
3) For the relevant Mainstream Beneficiaries, review their
    a) Annual financial statements as would be available on their investor relations website;
    b) Bondholder annual presentations as would be available on their investor relations website;
    c) Coverage in the financial press and media, such would be searchable on Google Finance;
    d) Foundation or government programs pledging to support the SDGs.
4) Use AI/ML to

a) Automate and update the expert tasks described in items 1 and 2;
b) Self-assemble reports for each Mainstream Beneficiary that describe operational critiques gleaned from reviewing its Financings that would justify funding Incentive Payments to Slumdwellers that improve QoLs (Section 16).

5) For Mainstream Beneficiaries that fail to collaborate,
   a) Send the report (item 3 (b)) to the bondholders' trustee;
   b) If the trustee fails to adequately respond, purchase a bond or share of stock issued by the Mainstream Beneficiary, and sponsor a bondholder or shareholder Resolution in support of making the Incentive Payments, to be voted on at the annual meeting of the bondholders.

Review surveys and reports from investment banks and other wealth management offices to compile a list of Donor-Advised Funds, corporate pledges and other capital pools that self-identify as supporting of one or more SDGs globally or in the country or region of concern.

18. Structuring financial instruments and arrangements that connect incentive payments to infrastructure investment, upgrades and maintenance in slums

18.1. How the module works and why it matters: Structuring connective financial instruments

As suggested in Section 16.1, numerous structures could be adapted or created to reward slumdwellers for playing their part in improving the QoLs and associated Flows, in cash, cash-like credits, land-tenure rights or other forms.

Digital financial technologies (**fintech**), insurance technologies (**insuretech**), legal technologies (**legaltech**) and government services technologies (**govtech**) can be used separately and in combination to deploy novel arrangements that are evidence-based driven by data about the QoLs, their Flows, the parties responsible and benefitted by them, and the slumdwellers' collective and individual roles in improving them. AI/ML applications can suggest innovative incentives that address common challenges faced by slumdwellers in order to address their personal and the slum's capacity for generating Flows to improve QoLs. In turn, data science can monitor for objective proof to clinically optimize and monitor the effectiveness of incentives as raising slum and regional sustainable resiliency. Section 18.2 suggests novel approaches to leveraging government finance and new technologies in ways that would dignify the work and commitment of slumdwellers to improving QoLs.

18.2. How to build the module: Structuring connective financial instruments

a) Government finance instruments:
   i) For the national, provincial and local governments responsible for the slum in question, summarize the terms of bond, leased equipment or other debt issued in their respective names or guaranteed by them, including the

historic interest rates, repayment terms and any incentives by way of forgiveness of principal or reduction in interest.

ii) To the extent available, ascertain how the proceeds of issued debt were used or authorized to fund infrastructure, assets or other capital improvements in QoLs, and trace the sensitivity of such desired QoLs to Flows involving the slum.

iii) For the national, provincial or local territory governed by the governmental unit debtor, consult with its debt's major credit rating agencies to determine how improvements in the territory's sustainable resiliency would improve such credit rating, and in turn, the lower interest rate its bondholders, equipment lessors or other creditors would be willing to accept, and calculate the "free cash flow" made available by reduced debt service costs over the next 10-year period.

iv) Using an agent-based probabilistic approach, project the annual incentive that the creditors would be willing to provide slumdwellers for playing their part in generating the "free cash flow" by assuring assets and infrastructure built by issued debt continues to perform its QoL's f-VaR function to assure favorable sustainable resiliency credit ratings continue throughout the maturity or refinancing of the debt.

v) As the government debt is retired, renegotiated or refinanced, add covenants that incorporate discounts for the government debtor using slum Flows to maintain and improve the sustainable resiliency.

vi) Create financial derivatives of multi-governmental unit debt that has sustainable resiliency incentives.

vii) Identify impact investors, banks, pension funds and SDG-aware financial institutions, and package participations and derivatives tied to sustainable resiliency debt as an asset class of evidence-based QoL improvement investments that such parties currently have difficulty quantitatively underwriting to become part of their portfolio allocations to SDG-aware investments.

viii) Produce a global and QoL thematic map showing the volume of slum-supportive investments, and how they perform (x) in growing sustainable resiliency locally, and (y) financially.

b) Fintech applications and business models:

i) With the personal financial management platform on the slumdwellers' mobile phones (see Section 16.2), track their financial health and wellness in order to find demographic patterns of need or strategies for success.

ii) As trust builds within the slum to adopt the fintech platform, use its data and client base to form a regulated independent cooperative or community bank to provide loans and financial services on more reasonable terms than money lenders, with the collateral being the individual slumdweller's accrued and forthcoming incentive payments.

c) InsureTech applications and business models:

i) Insurance will be an enormous incentive for slumdwellers to collaborate in using the GEM and its constituent Modules.

ii) Imagine a hypothetical slum whose residents behave perfectly rationally in adopting the incentives for contributing to improving the Flows and QoLs for which they can play a meaningful role. A Natural Disaster strikes, or other Major Adjustment Event occurs. All of the slumdwellers' "sweat equity" and trust in collaborating is about to be lost, and they will be turned into homeless persons, and perhaps stateless migrants.

iii) Through parametric or other mass casualty insurance, the slum as an economic unit might be moved to higher or safer ground on land controlled by the relevant national, provincial or local government, the structures could be replaced using prefab housing, agricultural processing and other pre-designed and rapidly manufactured technologies (construction technologies) and land tenure awarded based on individual slumdweller's prior or promised efforts. In the post-disaster pre-resettlement phase, slumdwellers would have temporary lodging with assurance of rebuilding. The catastrophic insurance premiums for the slum could be minor as compared to the QoLs that are threatened for ensuing years awaiting recovery and stabilization of conditions in the slum post-Major Adjustment Event [169].

d) Legaltech and Govtech applications and business models:

i) Survey the experience of slumdwellers, NGOs that have worked with slumdwellers and judges, prosecutors, defense counsel and the regional bar associations, to ascertain slumdwellers' economic, institutional, legal and logistical hurdles in seeking civil and criminal justice through the government's judicial system.

ii) Explore national and international law schools to find faculty and student groups engaged or interested in building legaltech applications that might reduce the hurdles slumdwellers face.

iii) Explore national and international technology startup incubators and university entrepreneurship, computer science and study abroad courses and alumni networks, through which to sponsor legaltech hackathons focused on developing mobile apps that would let slumdwellers learn about and request legal services in their native language(s) and indigenous cultural memes, pictorially, in words, in music or through other form of expression.

iv) Identify a first tranche of legaltech applications to be accessed via the slumdweller's mobile personal financial management app (see Section 18.2 (b)), by which to automate individual or group residents of the slum obtaining, through mediation or court process, the promised incentives earned via improving QoL Flows.

v) Identify a second tranche of legaltech applications, also to be accessed via the slumdwellers' mobile phone, that permit discovery of, and track the progress of applications for, government benefits, rights and remedies, such as housing subsidies, land grants, transportation and food vouchers, birth, death, marriage and divorce certifications, passport and visas, voting registration, small business grants, judicial settlements and escrows for the benefit of slum dwellers, employment and labor rights, etc.

19. COVID-19, a global pandemic as force for change

19.1. Pandemics are economically devastating

The history of regional epidemiological events demonstrates a persistent viral, causal and seasonal opportunism for people, animals, insects, birds, foods and goods that, by choice or circumstance, are increasingly globally mobile by airplane, ship, vehicle and changing weather patterns to carry infections from an isolated location to the entire planet in a matter of a few weeks [170]. Pandemics kill and maim large swaths of unprotected populations, instantiate novel public health risks and their costs of mitigation, destroy crops and livelihoods, shrink economies and topple whole empires, disrupting global economics, finance trade and security, and thus destabilize and reorganize international relations, from the fall of the Roman Empire, to the present day's challenges [171,172].

On 5 January 2020, the World Health Organization (**WHO**) reported on a total of 44 patients in Wuhan People's Republic of China displaying pneumonia-like symptoms from an unknown cause [173]. As of 13 June 2020, the Coronavirus identified as COVID-19 had spread globally to every nation, with 36,406 confirmed cases and 2048 confirmed deaths in Indonesia, as contrasted with 18 cases and no deaths in Fiji [174].

Public health interventions that accompanied government response to COVID-19 included ordering whole cities to shelter in place, closing international borders and freight transport, quarantining/banning international travel, disrupting supply chains and other measures that severely limited regional and national economic activity. These measures led to short-term business closures and bankruptcies (permanent closures), massive unemployment, loss of personal savings and investment, diminished value of retail, commercial and office real estate, and concomitant cascades of economic and social harms, especially burdening already low-income and demographically displaced persons. In the face of shrinking tax revenues from slower economic activity, most countries adopted and disseminated economic support and stimulus measures, albeit in halting clumps, and unequally to its citizens and businesses. Smaller countries increased their budget deficits and external debt by borrowing national COVID-19 response support and stimulus funding from sovereign reserves or global lenders. The Asian Development Bank (ADB) estimated that the economic impact of COVID-19—just for calendar year 2020—could be $8.8 trillion under various vaccine, containment and national response scenarios [175].

19.2. Fiji confronts the economic and social challenges of COVID-19

On 16 March 2020, Fiji saw its first COVID-19 patient, a 27-year-old male Fiji Airways flight attendant who traveled from San Francisco to Nadi in Fiji [176,177]. As of 18 June 2020, Fiji had 18 confirmed cases and no deaths from COVID-19 [174]. As a public health matter, Fiji's response to the pandemic was swift, strong and effective.

On 26 March 2020, Fiji's Ministry of the Economy, Revenue and Customs Service, and the nation's Reserve Bank jointly announced their preliminary

assessments of the pandemic's economic impacts: Massive disruptions to Fijian national economic and monetary interests caused directly or indirectly by COVID-19, including "massive decline" in tourism, significant contractions in the country's GDP, business sector, exports and trade flows, and massive deficits in expected government revenues from businesses, tourism and other taxes [178]. In response to the pandemic, Fiji allocated $3.54 billion—triggering a deficit of $1 billion, financed through a combination of sales of government assets and government borrowings from the Asian Development Bank and the World Bank, and pushing the national government's debt to 60.9% of the country's GDP, a 29% increase over the prior year's debt/GDP percentage [178].

19.3. Indonesia confronts the economic and social challenges of COVID-19

On 2 March 2020, Indonesia confirmed that two of its citizens tested positive for COVID-19 contracted from a casual contact on 14 February 2020, with a Japanese citizen who lives in Malaysia, tested positive for COVID-19 and so informed them on 28 February 2020 [179,180]. As of 17 April 2020, Indonesia had the highest number of COVID-19 cases in Southeast Asia [181]. As of 21 June 2020, Indonesia had 43,803 confirmed cases and 2373 confirmed deaths from COVID-19, the third highest in South-East Asia [174].

As of 17 June 2020, Indonesia had enacted four budget measures to combat the economic, health and social damage of the COVID-19 Pandemic totaling USD $49.63 billion, allocated as shown in **Figure 10** [182–184]. While the government's budget response allocated 29% to social safety nets and 13% to healthcare, none was identified as allocated to improving and mitigation housing, food, water, sanitation or other public health vectors of transmission to accommodate effective sheltering-in-place strategies. Constitutional scholars and anti-corruption government budget watchdogs have raised concerns that the emergency laws authorizing Indonesia's massive COVID-19 appropriations would shield officials and businesses accused or malfeasance, graft or corruption [185,186].

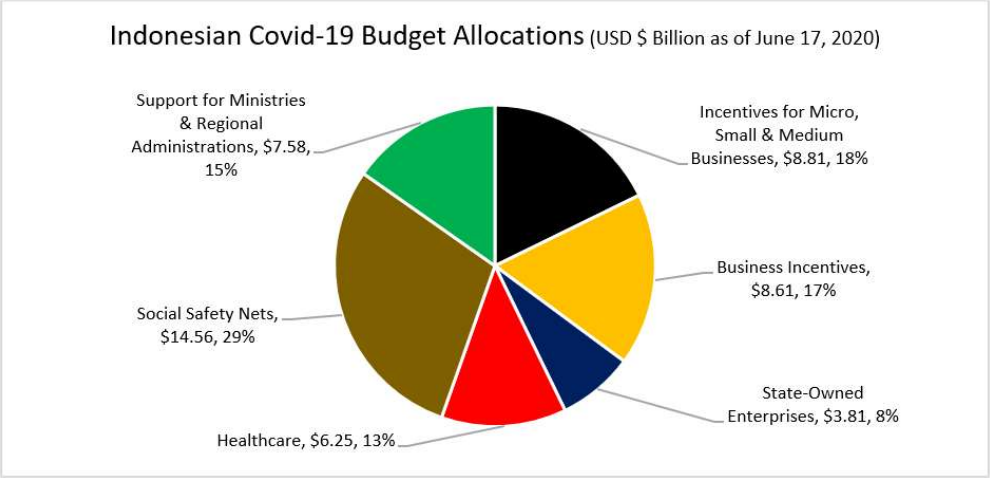

Figure 10. Indonesia's $49.63 billion COVID-19 response budget as of 17 June 2020.

The COVID-19 Pandemic caused huge reductions in travel, manufacturing and other economic activities. The sell-off in global commodity markets exacerbated the declines in government tax and export tariff revenues, such as from oil and mining royalties. Indonesia's budget deficit—still nominal by the standards of OECD Countries—swelled to 2.5% of GDP for 2020 and 2021 [187,188]. The COVID-19 Pandemic caused Indonesia to reorganize and restructure its gas, oil and other state-owned enterprises and lend them USD $8.6 billion to support their operations to mitigate the resulting economic disruptions [189–191]. For 2022, Indonesia's budget deficit will be 3.92% of GDP, despite increased revenues from commodity exports [192].

Indonesia is 87% Muslim [126]. Transmission of the pandemic in Indonesia coincided with the month-long Muslim holiday of Ramadan, following which vulnerable Muslims return from the urban centers to their villages, where the disease spread without adequate COVID-19 prophylaxis (clean water for handwashing and social distancing), symptom monitoring or treatment [193]. As Indonesia's Finance Minister Sri Mulyani Indrawati observed: "Despite an official ban on 'mudik', the annual exodus at the end of Ramadan, which this year falls in late May, many have since returned to their hometowns and villages across the country. It turns out preventing people from going back to home villages is nearly impossible" [referring to fears that travelers from the capital of Jakarta could spread the virus] [194].

As a result of the budget, economic and social disruptions of COVID-19, Indonesia's Finance Minister announced on 6 May 2020 that the government's progress in reducing poverty (SDG Goal 1) made over the past decade vanished: "All of our achievement in reducing the poverty rate between 2011 to 2020 is reversed" [194].

19.4. Takeaways from how Fiji and Indonesia confronted the economic and social challenges of COVID-19

While vastly different in demographic, geographic, economic and social structure and national heritage, Fiji and Indonesia highlight the human, economic costs and social challenges that developing countries face when addressing public health emergencies, such as the extreme case of the 2020 COVID-19 Pandemic, as shown in **Table 3**. Such extreme public health emergencies might lead government to prioritize funding SDGs for their vulnerable populations. Indonesia demonstrates the opposite: There the large shares of COVID-19 funding went to bolster state-owned enterprises and bureaucratic and corporate stakeholders in the country's formalized economy, leaving populations in slums more vulnerable and delaying the SDGs they were promised.

Perhaps the greatest takeaway from the Fiji and Indonesia COVID-19 responses are that the poor and marginalized in slums need to build permanent data-driven economic incentives for monetizing the mitigation value of their QoLs in reducing the costs and impacts compounding public health and other disasters that harm the formal economy.

Table 3. Statistical comparison of Fiji and Indonesia, including COVID-19 confirmed cases and deaths.

	Fiji	Indonesia	Source
Population (Millions)	0.944	277.3	[99]
COVID-19 Cases total—per 100,000 population as of 18 June 2020	18 cases 1.9 cases per 100,000	43,803 cases 16.4 cases per 100,000	[174]
COVID-19 Deaths total—per 100,000 population as of 21 June 2020	0 deaths 0 deaths per 100,000	2373 deaths 0.89 deaths per 100,000	[174]
2020 Budget Increase to Respond to COVID-19 total—per 100,000 population (as of 21 June 2020)	USD$ 3.54 billion $378.61 Million per 100,000	USD$49.63 billion $18.59 Million per 100,000	Section 19.2, Section 19.3
Human Development Index (HDI)—Country Rank	0.743–93rd	0.718–107th	[100]
Life Expectancy (years)	67.4	71.5	[100]
Landmass (square kilometers)	18,274	1,811,569	[99]
Independent Statehood	1970 (52 years)	1949 (73 years)	[99]
Poverty Rate: Living Below national poverty line	24.1%	9.6%	[100]
Inequality Index (GINI)	36.7	39.0	[100]
Corruption Perceptions Index	55–45th	38–96th	[102]
GDP (USD$ billion)	$4.6	$1186.1	[100]
GDP per Capita	$5086.0	$4291.8	[100]
Government Bond Credit Rating	S&P B + stable	S&P BBB stable	[105,106]
Government 10-Year Bond Yield	4.25%	7.365%	[107,108]

20. Leveraging local village financial management systems

Over the past several years, government finance professionals and academic researchers have begun to assess the impacts in Indonesia of improved systems for tracking village level spending, how the systems perform in use, and what impacts the systems creates. This Section 20 draws inspiration from such research and sees local financial systems as information infrastructure through which the GEM would operate and generate direct benefits to villagers.

20.1. Indonesia's poor live primarily in rural villages

As of 2021, 10.1% of Indonesians live below the national poverty line [195]. Indonesia's nonmetropolitan villages account for 65.1% of people living in poverty [196].

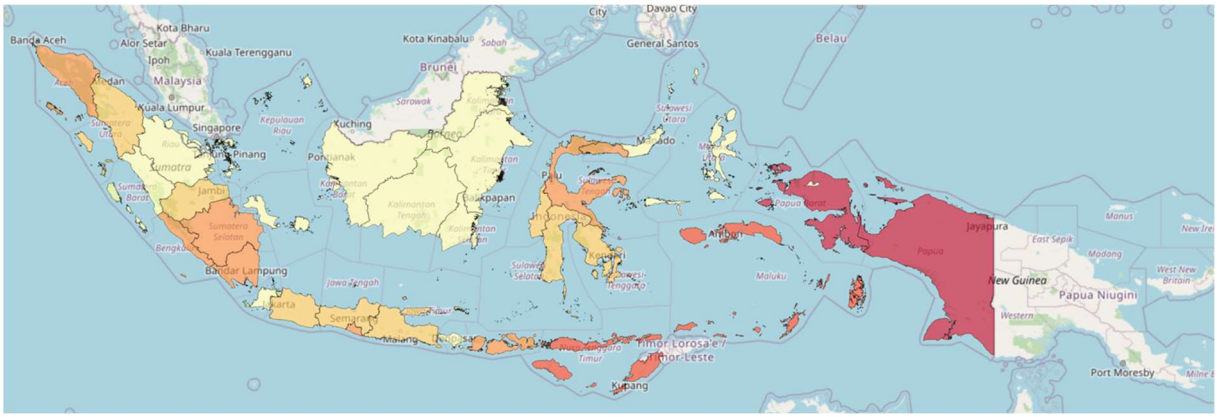

Figure 11. Indonesia poverty rate by province (2015).

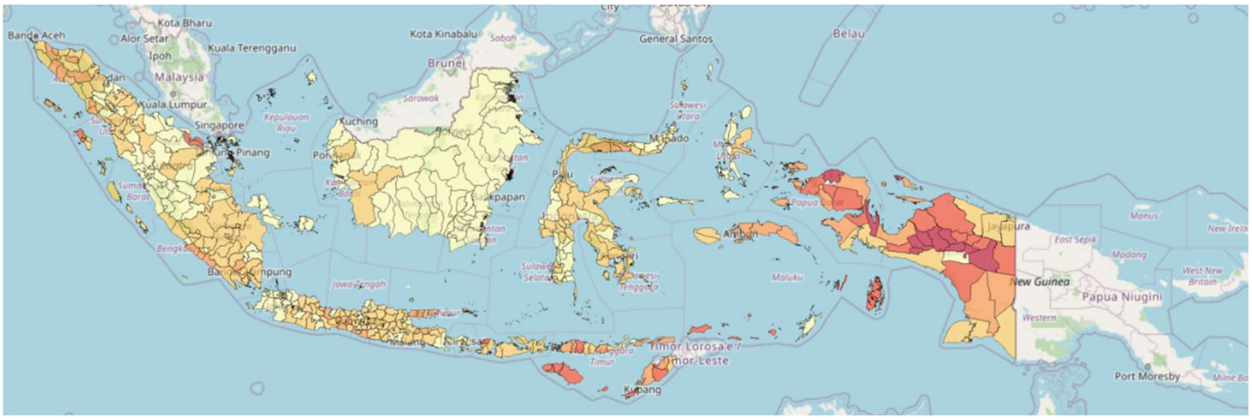

Figure 12. Indonesia poverty rate by district (2015).

To deal with poverty at its source, one must take a "hyper-local" view: The poverty rate at the sub-national provincial level needs to be traced to its district level and further to the geographic, economic and social conditions of the villages therein. Compare the provincial poverty map (**Figure 11**) [197] and the granularity of the district poverty map (**Figure 12**) [198].

20.2. Indonesia faces mounting disaster risks

Globally and in Indonesia, too often, the poor find what shelter they have in the excess land that is most vulnerable to natural hazard risk, pollution or other extreme conditions.

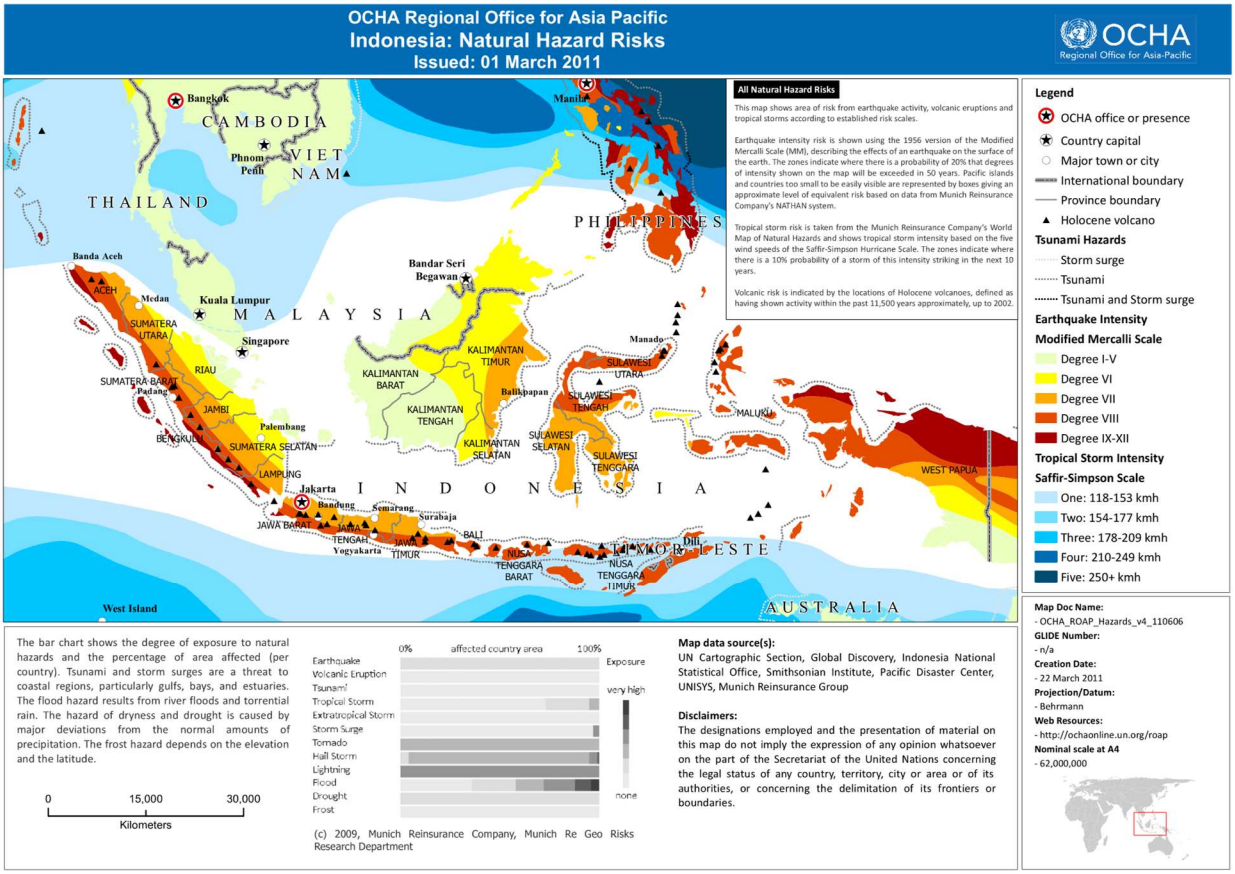

Figure 13. Natural hazard risks in Indonesia (2011).

Indonesia is situated on one of the most volatile fault lines in the world, and suffers regular incidences of earthquakes, tsunamis and volcanic activity. These phenomena also trigger other disasters such as mudslides, landslides and flooding. Indonesia's physical attributes result in a very high level of vulnerability for substantial number of Indonesians. Many communities across Indonesia are living in a constant state of risk, and these communities have little understanding about disaster risk reduction (DRR). Furthermore, government efforts in disaster planning since the devastating tsunami of 2004 have focused mainly on emergency response management. However, little has been done to encourage community involvement or any concerted efforts towards disaster mitigation (see **Figure 13**) [199].

Natural hazards do not stop or self-contain at the administrative borders of countries or their governmental provinces, districts or villages. Compare overlapping conditions depicted in Indonesia's Natural Hazards Risks Map (**Figure 13**) and the Provinces Map (**Figure 14**) [200].

Figure 14. Map of Indonesia's 34 provinces.

A holistic local approach would align contiguous districts and their villages to finance building resiliency, emergency response and post-disaster economic reimagination and social relocation services.

20.3. Corruption in Indonesia: An historic legacy and modern challenge

Corruption cheats the poor and working class, undermines business and public confidence in judicial independence and government fiscal accountability and responsible procurement, reduces the global financial credit ratings which increases interest rate and restricts development and corporate credit access, and ultimately wastes money and years that could improve Quality of Life across domestic and foreign environmental and social concerns [201,202]. Corruption is facilitated by organized crime, terrorist groups, human exploitation and other negative actors across international aid and development projects and global supply chains through the use of global financial markets [203].

In 2021, senior anti-corruption investigators and commissioners of Indonesia's Corruption Eradication Commission (Komisi Pemberantasan Korupsi or **KPK**) were dismissed, which dismissals further eroded domestic and international confidence in reform promises to hold those facilitating or profiting from corruption accountable [204]. Transparency International' Corruption Perceptions Index shows a consistently troubling trend of endemic corruption in Indonesia whereby the nation ranks 96th most corrupt out of 180 countries surveyed (See **Figure 15**).

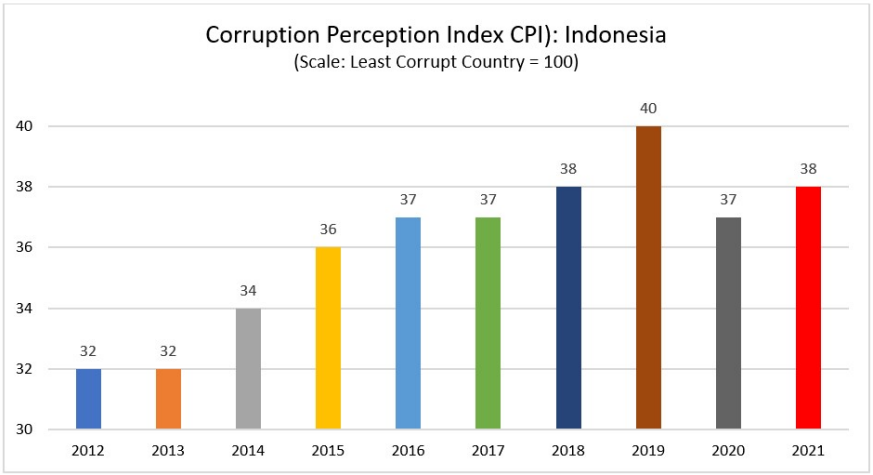

Figure 15. Transparency international corruption perception index for Indonesia (2012–2021).

Advanced statistical methods, automated through artificial intelligence (AI) machine learning (ML) technologies, make possible near real-time measurement of corruption perception sentiment based on news articles in mainstream media and other sources of "big data" [102]. With such advances, the financial and insurance markets will be ever faster in reacting to perceptions of corruption in Indonesia, and then will price corruption's costs, risks and waste into the interest rates charged on corporate, government and other debt, the premiums for investing in private companies and the additional reserves and constraints included in foreign development grants and loan programs.

20.4. Siskeudes, Indonesia's village finance information system

After colonial rule ended in 1950, as an independent nation, Indonesia progressed from autocracy to an increasingly responsive, inclusive and accountable governmental system [205].

Across Asia, Europe, Africa and Latin America, financial innovation at the village level reconnects national budget and policy goals (including the SDGs) with local decisions and impacts [206]. Towards the goals of reducing poverty and improving living standards, Village Law (No. 6/2014) (the **Village Law**) created a new era of locally directed and nationally accountable government finance, in devolving a major set of budgetary decisions to Indonesia's 74,953 villages, rather than reserving such decision-making to the districts in which they reside [207]. Devolving an annually assured amount of fiscal budget authority to the village government level recalled the decentralized governance Indonesia's pre-colonial

traditions [208]. The economic and political opportunity of the 2014 Village Law led larger villages to break up into smaller villages, which allows for more localized rule, as well as more autonomous opportunities for corruption and differentiated response to local conditions [209].

Soon after the Village Law was adopted, the internal audit agency attached to the Presidency (BPKP) developed a standard village financial information system (known as *Sistem Informasi Keuangan Desa* or **Siskeudes**) which nearly all villages have adopted [207].

20.5. Literature review of impacts of the village law

Implementation of the Village Law and its financial information system is only a few years old (2014–2022). A literature review was conducted to survey preliminary research studies as to the Village Law's impacts on fiscal budgetary integrity and consistency, and in turn greater transparency into village budget allocations to poverty, health, and other challenges.

Available research shows promising and, on balance, positive results from the Village Law. While village corruption remains a concern, the Village Law gives greater transparency into how village budgets from all sources are derived and spent. While a complete discussion of Village Law research is beyond the scope of this paper, relevant findings are worth highlighting as empirical foundations for augmenting the Village Law's impacts with a holistic fiscal budget derived approach, as the GEM provides:

a) Value of village financial information systems (**Siskeudes**):
    i) System information quality, information quality, and trust in technology have a significant impact on usage and user satisfaction, whereas service quality and trust in government organizations do not have such an effect [210];
    ii) As users perceive the value of using the information that Siskeudes generates (such as for analytical reports or to implement local policymaking goals), they are more likely to input data and comply with the data and metadata requirements of validating and maintaining the information system [211,212].
b) Improved government performance and accountability:
    i) With updated and more reliable annual data on village conditions, Siskeudes raises the levels of service quality, operational effectiveness and user satisfaction. Such benefits could be continuously generated, and village finance transparency and accountability could be improved, if annual Siskeudes reporting were made more frequent (monthly) [213];
    ii) Where village officials see the tasks automated by Siskeudes as irrelevant or extraneous to the criteria on which their performance is judged by government officials or villagers, they fail to participate in, benefit from or fully utilize the Siskeudes information system effectively [214];
    iii) The World Bank, the Australian Department of Foreign Affairs and other fiscal monitors and donors see Siskeudes as an evolutionary platform for increasingly granular data that can direct ever more targeted programs and

budget allocations to achieve improved village government performance and accountability [207];

iv) How the national, provincial and district governments relate to village governments is becoming more transparent, and their attention on local priorities is becoming more functional and transparent [215].

c) Human capital, competence and commitment:

i) When the village treasurer is capably trained and ethically committed to increasing the data provided to and made available for analysis from the Siskeudes system, the village's benefits and trust increase and fraud declines [216];

ii) A parallel series of benefits accrue to the village when village officials are competently trained and put the Siskeudes reports to regular use in managing village affairs [217];

iii) Without a standard operating procedure (**SOP)** and proper training and effective communication in why the SOP results in reliable and reusable data, the Siskeudes financial reports are not trusted or used by village treasurers and leaders [218];

iv) Siskeudes represents a sea change in how village administrators plan, implement and report on the use of village funds. Without commensurate training, the culture needed to take full advantage of Siskeudes' intended impacts will be inconsistent and delayed [219];

v) Technological change, to be meaningful, requires users to perceive receiving and being rewarded for the net value of reduced delays, uncertainties, inconsistencies and risks inherent in transforming prior processes while leveraging new capabilities. If the new technology (such as Siskeudes) performs as users expect and is also intuitively easy to use, it will be adopted and augmented in the villages [220];

vi) City villages and rural villages have diverse and distinctly differentiated governance traditions and capabilities. The village chiefs' relative lack of education and training in governance and using modern assessment, finance, planning and community engagement technologies and operations is relatively uneven and lagging across many villages outside of the major cities [221];

vii) The competence of human resources and village staff training, and the commitment of top management to implementation and ongoing experiential use of Siskeudes system data correlate with generating and trusting in higher quality village financial statements [222].

d) Fighting corruption using financial information system transparency:

i) By providing monthly reports, Siskeudes allowed Panggungharjo Village government to track budgeted vs actual cashflows, which timeliness and transparency reduces the leakage through which corruption might otherwise occur [223].

e) Addressing poverty, stunting and other SDG concerns using financial information systems:

i) Siskeudes funding could assure a relatively independent means for villages to implement SDGs of highest local priority [224];

ii) Siskeudes allows a new level of transparency as to how village fund allocations can be mapped to the SDGs [206].

f) Examples of information systems that village administrative staffs could use to increase the effectiveness of the village financial information systems:
   i) Remote sensing and geospatial analytics could speed targeting poverty, pollution and conditions that lead to health risks [225];
   ii) Since December 2004, Indonesia's national Ministries of Finance, Education and Social Affairs, as well as the World Bank, the World Food Programme and international and local NGOs have used geospatial analytics to address rural and village poverty, and the planning and administrative processes for alleviating conditions that exacerbate village poverty [226].

20.6. How Indonesian village finance might leverage the GEM

Permatasari et al research made a significant methodological contribution in showing how to map Village Fund activity codes to SDG Goals in Indonesia [206]. Permatasari et al found that significant SDGs were not being allocated Village Funds in the prioritizations that would optimize local QoL elements such as sanitation and health [204].

The GEM is a next step optimization model to leverage the fiscal authority, continuity and strength of Siskeudes to achieve the locally relevant mix of nation-scale SDGs as a synergistically quantifiable investment portfolio whereby the Village Fund allocations in clusters of local activities reinforce each SDG through a stream of QoL impacts. Discussions of how to make decisions or to review past decisions in the use of Village Funds require a capacity to test "what-if" assumptions for which clusters of activities would most urgently improve slum QoLs, and how to communicate the quantifiable logic of such alternative fund allocations within the village, and to district, provincial and national leaders. Finally, the GEM allows for a new currency of engagement to evolve whereby the actions of slumdwellers in mitigating high priority SDG/QoL concerns represent further development of financial innovations that add to the monetary amounts of Siskeudes funds available in any given year.

As Indonesia, its villages and the people living there respond to and take steps to mitigate the effects of poverty (Section 20.1), natural disaster risk (Section 20.02), corruption (Section 20.3) and other threats, a shared approach to gauging and prioritizing QoL vulnerabilities and programs across village, district and provincial boundaries and jurisdictional authorities must be employed. The GEM with Siskeudes fiscal transparency data can be powerful tools for mustering the will and transparency to visualize, fund and surmount such challenges in their regional context.

21. Conclusion

The economics of slums, once fully contextualized and leveraged, provide unique opportunities for upgrading health, housing, water, sanitation and other SDGs. Emerging trends in our partial and situational understanding of slum life and

its diversity of challenges [16] require mechanisms for catalyzing, recognizing and rewarding people living in slums to design and take local actions. The data to drive evidence-based incentives for responsible activities in the slums is becoming readily available in open-source interoperable forms or through standardized government digital accounting platforms on a near real-time basis. By speaking in the budgetary language of national, regional and local government, the Periodic Table of Quality of Life Elements traces the savings from improving QoLs in order to improve government bond ratings, which improvements raise credit ratings and reduce government bond debt service and borrowing costs, freeing up cash flow in fiscal budgets to pay slumdwellers a share of the savings as incentive fees. Personal financial management applications on slumdwellers' mobile phone permits responsibly paying incentive fees and fosters financial inclusion and literacy. Innovating a full range of fintech, legaltech, insuretech and govtech services developed specifically for slumdwellers has a higher likelihood of adoption and use once the incentives for QoL improvements build ongoing trust in the economics of the slum and the outside world.

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