UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Predictive Modelling, Complexity Analysis and Assessment Barometer for Gender-Based Violence Evaluation: A System Dynamics Approach

by

Shané Swanepoel

(u17003556)

Submitted in fulfilment of the requirements for the degree

Master of Engineering (Industrial Engineering)

at the

Department of Industrial and Systems Engineering
University of Pretoria

24/06/2022

Abstract

Gender-Based Violence (GBV) is a social problem that has grown in magnitude, severity and complexity in recent times. Social, human systems like the GBV presents unique challenges that span across various disciplinary boundaries, hence making it difficult to proffer a sustainable solution. Currently, there are a very limited number of engineering-based solutions available in this problem space while most solutions being proffered by the social science disciplines are mostly human centred with little or no holistic considerations or systems thinking and dynamics. This makes it difficult to replicate such solutions in the diverse human societies. It is on this ground that this research has proposed a holistic and integrated engineering-based solution, premised on systems thinking principles, to address GBV as a complex social problem. Thus far, a need currently exists for a more reliable and comprehensive solution mechanism in order to significantly minimise the occurrence of GBV and its conglomerative effects on individuals and the society at large. The specific objectives addressed in this research include: the development of a holistic and integrated network of GBV driving factors with the aid of systems thinking; prioritisation and quantification of the identified GBV driving factors for further objective analysis; modelling of the complexity of the GBV problem for proper management guidance towards the provision of effective solutions and lastly, adaptation of the GBV solution mechanism to an interactive dashboard to serve as a measurement barometer capable of assessing and estimating the likelihood of GBV occurrence between any two interactors of the opposite genders. This research has utilised a case study research methodology in combination with different engineering-based problem-solving mechanisms premised on the Hybrid Structural Interactive Matrix (HSIM) for prioritisation of the system drivers while Systems Thinking and Systems Dynamics principles were utilised towards gaining holistic understanding of the depth of interaction amongst the diverse driving factors and how the system behavior changes over time. In a mostly data-less system with qualitative centred driving factors, the quantification and analysis of the system was made feasible through the generation of weights emanating from the prioritisation process of the driving factors. The weights as applied in this research are symbolic and were used to understand the criticality status of the driving factors and their corresponding analysis. Based on the symbolic quantification per driving factor as generated in the prioritised weights, complexity analysis was carried out on the GBV system of factors by deploying the spider diagram approach effected on three separate iterations. Different levels of complexity were arrived at viz 95.2748%, 95.2341% and 95.2662% respectively for iterations 1, 2 and 3. The

implication herein is that the operational dimension of these factors from a holistic point of view poses a high level of complexity hence requiring a significant management effort. Furthermore, by varying the weights of selected factors, sensitivity analysis was conducted using the system dynamics methodology. However, this was preceded via the development of a comprehensive causal loop diagram premised on the system drivers as a measure towards understanding the intricacy of interactions per driving factor. This was followed by the stock and flow diagram development for dynamic simulation over a horizon period of 100 months. Different intervention measures were proposed in respect of managing the top driving factors on the hierarchy diagram which are considered to be critical to the GBV system. These factors in a descending order include: gender equality, education equality, income generation opportunities, pandemic situations, population density related problem and lastly health and health care driving factor. The six most prioritised factors were considered as the KPIs for the GBV system. These were utilised to develop a simple GBV barometer for assessment of the likelihood of GBV occurrence for both victims and perpetrators. Three case scenarios were hypothetically explored and validated to ascertain the functionability of the GBV system. The output from the system was categorised into such responses as low, moderate, medium and high likelihood of GBV perpetration. In a nutshell, this research has provided a comprehensive objective architecture for GBV analysis, evaluation and mitigation. It is hoped that with the availability of datasets for specific drivers, more simulation-based studies can be conducted for an enhanced GBV management process.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AHP	Analytical Hierarchy Process
CLD	Causal Loop Diagram
DV	Domestic Violence
GBV	Gender-Based Violence
HSIM	Hybrid Structural Interaction Matrix
HTSD	Hierarchical Tree Structure Diagramming
IPV	Intimate Partner Violence
ISM	Imperative Structural Modelling
KPI	Key Performance Indicator
MDCA	Multiple Criteria Decision Analysis
SD	Systems Dynamics
ST	Systems Thinking
SV	Sexual Violence
QMF	Quality Management Factor

Chapter 1
Introduction

1.1. Background

Gender-Based Violence (GBV) is a term that represents the violence committed against an individual or group of individuals due to their gender or gender role within society. GBV can be committed against both men and women, but studies indicate that this type of violence is more prevalent amongst women and girls. The World Health Organisation (WHO) conducted a study in multiple countries on how a women's health is affected by domestic violence. This study indicates that the majority of reported GBV cases are committed against women by men. This study also found that the perpetrators are often known by the women (García-Moreno et al., 2005).

GBV is a term commonly known today but was initially introduced in the 1960s in some western countries. It is rooted in gender inequalities and the abuse of power over certain gender roles in different societies. GBV describes harmful and violent acts directed against an individual due to their gender. It exists in many everyday relationships, including intimate, opposite-sex, family, or work relationships, to name a few. Research indicates that GBV is a serious human right violation with life-threatening consequences that can be committed against any gender, race, religion, or ethnicity, thus making it complex.

Gender-Based Violence (GBV), like most societal social problems, has grown over the years to become a major crisis. While social problems in the class of the GBV are quite diverse, there have been very limited engineering-based solutions for addressing this societal menace. Most solutions proffered over the years from human-centred disciplines such as management and social sciences are considered to be mostly non-holistic as these, lack the view of systems thinking. It is critical to understand the degree of complexity of this social menace for effective and proper management guidance to ultimately have a human society with extremely reduced cases of GBV.

GBV undermines laws specifically created to fight gender discrimination and which foster human dignity. This phenomenon impacts its victims not only physically, but also burdens

them emotionally and psychologically, and can affect their behaviour. According to the World Health Organisation (WHO), GBV is a public health problem worldwide which affects one in three women (World Health Organization, 2021). History shows that women are more susceptible to these violent acts, commonly inflicted by their male counterparts (Mile, 2020). GBV does not only impact individuals during adolescence and adulthood but also other life phases such as infancy, childhood and old age.

It is not only the victims and their family members that are affected by GBV, but also a society or a country at large. GBV is a widespread and long-standing problem in South Africa (SA) and has an impact on various facets of its citizens' lives. With rampantly growing prevalence rates, SA is seen as a country with one of the highest numbers of rape and femicide cases globally (Mile, 2020). This is alarming as GBV only receives occasional media coverage despite the seating president declaring GBV a national crisis which has resulted in several women and children suffering from the brutal crimes associated with GBV.

Various societal and systematic factors continually exacerbate GBV rates in the country. GBV is a problem that has been faced by many individuals at higher educational institutions for many years. Saferspaces (2022) argued that research in this field is lacking and thus hampers efforts towards an understanding of the true nature of this phenomenon. They state that these institutions often do not recognise GBV as a major problem due to under-reporting of this type of violence. This under-reporting makes it difficult to measure the prevalence and severity of this problem, ultimately affecting prevention efforts (Finchilescu and Dugard, 2018). Studies find that it is not enough to simply view GBV at these higher educational institutions as a security problem and that it can only be effectively addressed if specific measures are developed that change the overall culture and underlying social norms at these institutions (Collins et al., 2009).

The South African constitution has developed policies that fight GBV and protect women and children from these crimes. The implementation of these policies does however remain a problem. Mile (2020) argues that the implementation of GBV prevention strategies and policies are hampered due to a lack of the following factors:

- *Effective Criminal justice system:* the current criminal justice system fails GBV victims, as very few of the cases that are reported leads to conviction.

- *Care from police officials:* victims are often not treated with care or taken seriously by police officials. This behaviour creates an unsafe environment for these victims and minimises the chances that they will report similar matters in the future.
- *Preparedness of police stations to take rape reports:* In many instances, a police station does not have the necessary equipment and rape test kits to effectively take rape reports of victims and deny the rape victims any reporting credibility.
- Accountability within a community
- Support and care for victims
- Urgency in the government response

Addressing GBV is a crucial part of the UN Women's organisation and forms part of their sustainable development plan (UN Women, 2022). The equality and empowerment of women is one of the organisation's 17 sustainable development goals. They emphasise that women and girls globally receive equal opportunities and human rights. They also seek that women and girls freely live without any discrimination or fear of violence. In short, all of this is encompassed in their strategic development goal (SDG) number five, aiming to empower all girls and women and achieve gender equality. Achieving this goal by 2030 requires that action be urgently taken to eliminate and address all the root causes of this type of violence and discriminatory behaviour that curtails the rights of women and girls in the public and private sectors.

The strategies deployed in GBV are forever changing and facing an increase in complexity and diversity. It is challenging to develop solutions that will effectively address the problem of GBV, due to a lack of comprehensive research in this field, under-reporting, scarce response mechanisms and the gender-specific discriminatory nature of this phenomenon (Saferspaces, 2022). The solutions in this field are often inadequate as human-centred disciplines often provide simple to non-holistic solutions to this class of complex societal problems. This gives in to the notion that one solution fits all circumstances (Jackson, 2006). These simple, quick fixes often fail because they are non-holistic and only focus on specific parts of GBV, rather than the system as a whole.

1.2. Problem Statement

Violence is one of the main causes of death around the world. Violence and violent behaviour are evident and normalised in many cultures and societies. This normalisation occurs due to societies' sense of gender privileges and rigid social norms which often use violence as a way of justifying violent behaviour. Researchers have found it difficult to classify the types of violence that fall under the category of GBV, as GBV is a complex and diverse problem with no defined system boundary.

GBV continues to exist in many societies around the world and affects its victims physically, emotionally, and mentally. The surge in cases of GBV in recent times has reached an alarming rate. Statistics South Africa (Stats SA) has recently estimated that approximately 21% of women aged 18 years and above have personally experienced or have been affected by physical violence (or a form thereof) by an intimate partner. They also estimate that approximately 6% of all women will experience or be exposed to sexual violence during their lifetime (Enaifoghe et al., 2021). It is however commonly believed that the reported GBV numbers in South Africa are inaccurate and not representative of reality, as many GBV cases in the country go unreported. Even though many prevention strategies for GBV do exist, accurate and robust statistics of GBV's prevalence rates and manifestations are scarce.

South Africa is described as a dangerous and life-threatening place for women to live and records the fifth-highest rate of femicide globally (Interim Steering Committee, 2020). Stats SA has recently published that intimate partner violence (IPV) rates in South Africa are high when compared to global statistics and states that sexual violence (SV) and rape are hyper-endemic in the country.

In a survey conducted by Stats SA in 2018/19 on Governance, Public Safety and Justice, it was determined that approximately 29% of assaults committed in South Africa were perpetrated by an unknown person, 13% by a relative, family member, or person living in the same household, 15% by an intimate partner or spouse and 22% by an acquaintance or friend. In total, approximately 50% of these offences were committed by someone whom the victim knew or was close with (Stats SA, 2021). These statistics are presented in Figure 1.

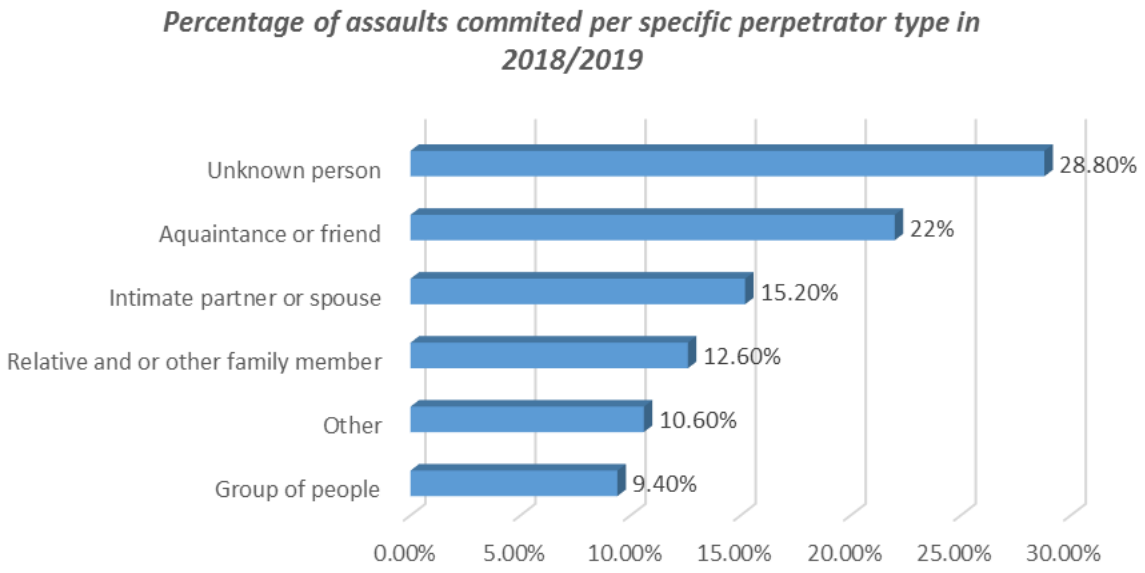

Figure 1: Graph of percentage assaults committed per perpetrator type in 2018/19

The United Nations Women Organisation indicates that the cost of GBV (specifically violence against women and girls) amounts to approximately two per cent of the global gross domestic product (GDP). According to UN Women (2016), women who experience or are exposed to IPV are absent from work at least five paid work days (per incident of IPV) more than women who do not experience this kind of violence. This means that these women's salaries can be up to 25% lower (each time they are exposed to these violent events) than what they would have earned under normal circumstances. The UN Women's research indicates that women who are exposed to or who experience GBV (specifically IPV) are mostly employed in part-time or casual work environments and annually earn approximately 60% less than women who do not experience this violence and who are employed in other sectors.

KPMG (2022) performed a study on the cost impact of GBV on the SA economy. This study found that GBV impact the economy between R28.4-R42.4 billion (representing between 0.9%-1.3% of the country's GDP. This study found that women experiencing GBV are absent from work (above their normal vacation and sick leave days) five days more on average per year (assuming a work year with 20 work days per month).

Problems that we currently face often emerge as unintended consequences of previous solution attempts. Social, human systems like that of GBV present unique challenges and are difficult to solve as the system spans different disciplinary boundaries and has been present for a long time (Sterman, 2002). The need exists to develop accurate and reliable models for human behaviour and social systems. To successfully change social systems and reduce their impact

on individuals and society, active participation is required from a wide range of people and disciplines.

In today's world of constant change and accelerating complexity it is important to recognise that the current tools being used to address complex social problems have not only failed to solve the ongoing problems we face or reduce its impact, but may be the very factor(s) that is causing them. It is frequently seen that the well-intentioned efforts put in place to solve pressing and challenging social problems lead to unanticipated and unexpected consequences.

For solution attempts to be effective, engineering disciplines must consider the social, ecological, economic, political and/or any other impacts of the proposed solution(s). If they fail to do so, the proposed solution attempts may lead to unexpected consequences that can cause damage to human health and welfare, and to the proposed engineering solution failing too.

1.3. Research Questions

This research seeks to answer the following research questions:

i. What are the driving factors of GBV?

ii. How can the GBV driving factors be prioritised with the assignment of a weight per identified factor?

iii. How can the complexity of GBV as a complex social problem be modelled?

iv. In a bid to assist individuals to know themselves better, how can the act of perpetrating GBV by an individual be assessed with the display of a quantitative output for ease of categorising persons into subgroups for a follow-up counselling procedure?

1.4. Aim and Research Objectives

An aim and clearly defined research objectives have been defined in Section 1.4.1 and Section 1.4.2 that follow, to effectively address the various research questions that have been identified for this project.

1.4.1. Aim

This research aims to develop an integrated and holistic engineering-based solution; premised on system thinking principles to address GBV as a complex social problem. This novel social engineering approach serves to supplement existing literature on GBV problem solving.

1.4.2. Research Objectives

The objectives of this research are to:

i. Develop a holistic and integrated network of GBV driving factors premised on systems thinking.

ii. Prioritise these factors with an approach capable of assigning weights to the hierarchy of factors.

iii. Model the complexity of the GBV problem for proper management guidance towards the provision of effective solutions.

iv. Utilise a GBV interactive dashboard to serve as a measurement barometer capable of assessing and estimating the risk of GBV occurrence between any two interactors of the opposite gender.

1.5. Rationale

GBV is a complex problem that has not yet been effectively solved. Russo and Pirlott (2006) state that social differences are dynamically complex and argue that the interconnected relationships that exist between gender and other social factors should be understood. Although many prevention strategies, summits, webinars, and media awareness exist on this topic, none have been completely successful in addressing GBV.

Many non-holistic studies have been conducted in this field, addressing underlying GBV causes and their impact. Very few however address the complexity of GBV through a holistic system thinking approach. Systems thinking provides the opportunity to analyse all aspects of a problem and consider both past and current events. A holistic and integrated approach to address GBV as a complex social system can improve one's understanding and knowledge of the complex, intricate nature of GBV and the interconnectedness of system elements. This will improve future solution development attempts and respond to the challenge of complexity in social systems.

1.6. Motivation

This project is motivated by a GBV, existing solution and a South African perspective in the paragraphs that follow.

1.6.1. GBV Perspective

The recent Covid-19 pandemic serves as one of the greatest motivations for this project. The Covid-19 pandemic has revealed and aggravated the inequalities of different societies and genders across the world. Dlamini (2021) argues that GBV should be seen as a "Twin-pandemic" to Covid-19 and that the same amount of effort and government attention should be given to GBV to address it. In 2020 when countries were shut down, and societies entered into compulsory lockdowns to fight the Covid-19 pandemic, GBV became more prevalent and a sharp increase in GBV cases has been observed globally. Some even argue that women across the world were (and in many cases are still) trapped between two pandemics, namely the Covid-19 pandemic and GBV.

1.6.2. Existing solution perspective

Solutions in the field of GBV are often inadequate and fail to effectively address GBV as a social problem. Most solutions presented over the years originate from human-centred disciplines and exist in the form of prevention strategies, media awareness campaigns, summits, and webinars. The World Health Organisation, for example, has identified prevention strategies to address interpersonal violence, including GBV (World Health Organization, 2010), but argues that even though these strategies have been implemented globally, they are not completely successful as the parameters and scope of violence change regularly. These solutions are mostly non-holistic and do not address the problem of GBV as a whole. Currently, a very limited pool of engineering-based solutions exists that is capable of addressing GBV. This can be attributed to the ever-changing nature and complexity of GBV and the lack of comprehensive statistics in this field.

1.6.3. South African GBV perspective

The South African Medical Research Council (SAMRC) claims that GBV is both a problem in the South African and global context. They state that one out of every three women in the country has been exposed to or has experienced IPV in the past 12 months. The University of Pretoria recently held a panel discussion webinar, where they discussed GBV and Femicide in South Africa. In this discussion, it came to light that perpetrators often get away with their violent behaviour and crimes as the current system in South Africa is weak and does not have sufficient capacity to deal with these problems. It was also noted that the countries' failure to

appropriately plan for these types of problems is one of these systems' biggest weaknesses (Maseka, 2021).

1.7. Scope of the Research

The scope of this research entails designing a holistic and integrated engineering-based solution to address GBV as Complex Social Problem. A GBV system will be defined and clear system boundaries established. This system will be modelled and evaluated using appropriate Systems Thinking (ST) and System Dynamics (SD) techniques. A GBV Key Performance Indicator (KPI) interactive dashboard will be developed capable of serving as measurement a barometer where the likelihood of GBV occurrence between two individuals (of the opposite gender) is accurately predicted. The application is performed using existing software packages. This project is premised on Systems Thinking and Systems Dynamics principles and is focused on using weight-based modelling during analysis to assign quantitative weighted numerical values to qualitative inputs.

1.8. Limitations of the Research

The limitations of this research include:

i. The project focus is limited to individuals who are exposed to, who experience or who themselves perpetuate GBV.

ii. This project and its review of literature is limited to the availability of current and existing engineering-based solutions for social problems, such as GBV.

1.9. Delimitations of the Research

Delimitations of this research include:

i. Data required for this research will not be collected via the distribution of research instruments rather, they will be partly generated and also collected from secondary sources (such as internet sources, journals, textbooks, magazines etc.).

ii. No humans will be used as informants or will be interviewed to collect data, as people are often biased about social problems.

iii. This project focuses solely on the development of an interactive dashboard therefore this project will not focus on the testing and or implementation of the developed dashboard on humans.

iv. The dashboard will not be coded from scratch, but existing software packages will rather be utilised for development purposes.

1.10. Organisation of the Research

This research report contains five chapters, in which the issue of GBV as a social complex problem is investigated. Chapter 1 serves as an introductory chapter for this research and provides background information and details of the existing solution space for this topic. A problem statement is clearly defined, emphasising why GBV is an issue that needs attention and why pursuing a study in this research space is important. Four research questions and their corresponding research objectives have been identified. This chapter also contains details on the research aim and rationale behind this study.

An in-depth literature review is provided in Chapter 2 of this report. Fields researched and included in this review are GBV and its current prevention strategies, systems thinking, systems dynamics, decision-making methodology, and prioritisation methodology environments separately. This chapter also proposes an alternative and a preferred solution to address the issue under investigation. This preferred solution served as the basis from which the conceptual and theoretical frameworks were developed.

Chapter 3 of this research report contains the conceptual and theoretical framework of this project. The conceptual framework serves as a visual representation of the research methodology to be followed for this project. The theoretical framework is used to explain and elaborate on the relevant theories, techniques, and steps to be followed during the analysis phase of the research methodology. Chapter 4 and Chapter 5 of this report contain the data presentation, results and concluding remarks for this research, separately.

Chapter 2
Literature Review

2.1. Gender-Based Violence (GBV)

In a study carried out by Krug et al. (2002), violence, in general, was divided into three main categories and corresponding subcategories, based on the type, setting, and nature of violent behaviour and acts. The three categories are interpersonal violence, self-inflicted violence and collective violence which are shown in Figure 2.

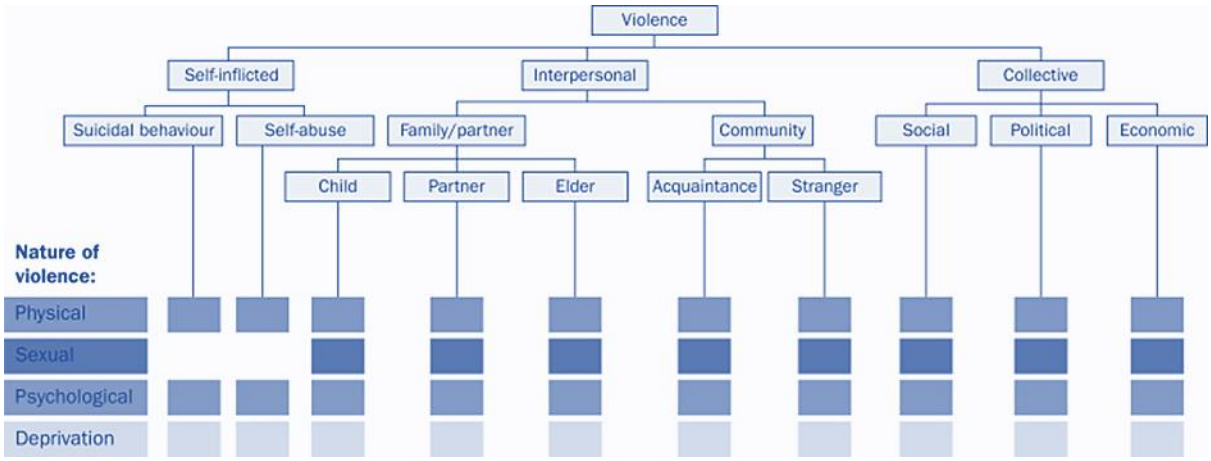

Figure 2: Categories of violence (Krug et al., 2002)

GBV is described as a public health crisis that poses various barriers to development and human rights. GBV originates from power contracts that exist between men and women within a personal, community, or societal setting and exist in many forms including:

- ***Violence against women and girls (VAWG)***
- ***Intimate partner violence (IPV):*** This is described as the most frequently perpetrated type of GBV and can take place in opposite-sex and or same-sex relationships. This form of violence includes sexual, emotional, and physical abuse and sometimes controlling behaviours by a former or current intimate partner(s) (World Health Organization, 2013).
- ***Domestic violence (DV):*** This type of violence refers to violent acts which are carried out by an individual's partner(s) or family members against them. It can also refer to the violence directed towards other family members or children.

- ***Sexual violence (SV):*** Krug et al. (2002) define this form of violence as any sexual actor attempted sexual act against a person by using force, perpetrated by any person in any setting.
- ***Violence directed against the LGBTI community:*** this form of violence is directed toward any person who society identifies as not conforming to their original assigned gender roles. Individuals who experience this type of violence identify as lesbian, gay, transgender, intersex, and or bisexual.
- ***Indirect structural violence:*** This form of violence exists when certain societal groups, genders, nationalities, or classes have favoured access to resources, opportunities, and goods over others within the society. It also occurs when this unequal advantage and privilege is integrated into the social, economic, and political governing systems in a society.
- ***Intimate partner femicide:*** This type of violence is committed against an individual by a former or current intimate partner (of the same or the opposite gender).
- ***Non-intimate partner femicide:*** This is seen as the most extreme form of GBV and refers to the killing of an individual, by another person (other than a former or current intimate partner), including an acquaintance, a stranger, a relative, or a family member (Maseka, 2021).

GBV has become a major problem in South Africa in recent times. Between 1 April 2021 and 30 June 2021, South Africa recorded a higher number of rape cases, than Covid-19 death cases due to the third wave of the pandemic (Vivier, 2021). Statistics that are of even greater concern are that approximately 161 cases of sexual offence and or sexual violence cases have been removed from the court roll since December 2020 and that 10086 SAPD police officials have been accused of violent acts like rape, harassment, and murder since 2012 (Maroela Media, 2021). It is alarming to note that only 50 of the police officials that were found guilty of these crimes were suspended from service.

The question we have to ask ourselves is: “How can we expect that GBV will be addressed and interventions effectively enforced if the countries police service is filled with corrupt officials?”. Research states that two out of three women will experience or be exposed to either sexual or physical abuse (or a combination of both) in their lifetime and that these numbers may even be higher in rural areas where gender inequalities have led to the normalisation and internalisation of violence among women.

GBV has had an immense negative impact on individuals and societies not only in South Africa but around the world. GBV is currently recording some of its highest cited rates in decades, and awareness of the topic of GBV is growing. When addressing this topic, emphasis should be placed on the causes and contributing factors of GBV, and not only look at the consequences and impact that it has on its victims. This is necessary, as the identification of relevant causes can aid in and lead to an improved understanding of the problem of GBV.

2.1.1. Causes of GBV

The Centre for the Study of Violence and Reconcilliation (2016) released a brief review in which GBV, specifically in a South African context, was discussed. This review found that many factors cause GBV and influence the GBV prevalence rates in South Africa. The causes identified in this study are religion, cultural practices and traditions, gender stereotypes, gender norms of a society, personal factors, individual factors, economic and societal factors, substance and alcohol abuse, and patriarchy to name a few. This study highlights how these causes interrelate and what impact these causes have on GBV.

Jacob Tema, a social worker at Rays of Hope in Alexandra, aims to address and minimise GBV that exists within the township. Tema states that anger is at the heart of GBV and that only a deeply angry person will consciously choose to inflict physical, sexual, and emotional abuse on another individual. He believes that anger within individuals stems from a clash between traditional values and that of modern society. He also states that this anger becomes even more complex in situations where both partners in a relationship are employed, or where the female earns more than the male. This anger comes from traditional norms and the belief that men should be the main breadwinners in a household. Patriarch also forms a backdrop to GBV according to Tema. He states that women are conditioned to believe that their partners are entitled to inflict harm on them if these women are completely economically dependent on their partners (Vivier, 2021).

The causes of GBV are complex and occur at various levels of society namely, individual level, relationship level and community level (World Health Organization, 2020). Risk factors evident at an individual level include elements of personal and/or biological history that influence an individual's behaviour. At a relationship level, one has to consider the close relationships that exist between family members, peers and intimate partners, and how these relationships increase the risk of either experiencing or perpetrating GBV. Finally, at a

community (or societal) level the norms and acceptable normalised behaviour of that specific society should be taken into account.

The WHO provides fact sheets which detail the important risk/causal factors that lead to violence against women (World Health Organization, 2021) and children (World Health Organization, 2020) at these various levels, as briefly listed in Table 2 on the next page. This list is not exhaustive and many additional factors can also be identified.

These identified causal factors demonstrate the magnitude of the GBV environment and its origins and emphasise why multi-sectoral responses are required to coordinate and implement successful intervention measures.

2.1.2. Current prevention attempts

Current interventions in the GBV environment originate from many disciplines and defined approaches. The GBV Sub Sector Working Group - Nigeria (2017) defines four approaches that guide GBV prevention strategy development. These approaches are discussed in Table 1 below. One should note that an engineering-based intervention approach is not presented in this sub-section, as current literature on this is scarce and lacking.

Table 1: GBV intervention approaches

Approach	***Discussion***
Survivor-centered	This type of prevention approach creates an environment for survivors that support these individuals' dignity, respect, human rights and safety. This approach is based on safety, respect, confidentiality and non-discrimination as guiding principles.
Community-based	This approach relates to the protection and assistance of affected societies and or populations.
Rights-based	This prevention approach analyses and addresses the various root causes of inequality and discrimination in different societies.
Humanitarian	Humanitarian principles should underpin and guide the implementation of different GBV prevention strategies to ensure that the humanitarian response attempts are effective.
Do no harm	With this approach all the necessary measures are taken to avoid exposing individuals to any more GBV harm and or risks.

Table 2: GBV Risk factors at different levels

Causal factors at an ***individual level***	Causal factors at a ***relationship level***	Causal factors at a ***community/societal level***
- biological and/or personal factors including age, race and sex - low income or opportunities for economic advancement - low levels of education - substance abuse (i.e. Misusing alcohol and drugs), - having mental health problems - having a history of being exposed to violence - identifying as or being identified as part of the LGBTI community - exposure to maltreatment as a child - etc.	- witnessing parent violence as a child - exposure to violence between caregivers - lack of emotional bonding with parents or caregivers as a child - family separation/dysfunction - family honour - growing up with poor/lacking parenting practices - early and/or forced marriage - having multiple partners - attitudes that disregard violence - miscommunication between partners; and - controlling behaviours between partners - etc.	- high levels of poverty - low income and economic advancement opportunities - lower levels of paid employment opportunities for women - low gender equality within a community/society - high population density - high levels of drug dealers/gangs - low levels of social cohesion and unity - temporary populations - easy access to alcohol/ easy access to firearms - social and gender norms - sexual entitlement ideologies - weak sexual violence legal punishment - normalisation of violence and violent practices - economic, social, educational and health policies - absent, inadequate and lacking social protection

The United Nations entity for gender equality and women empowerment has identified and described ten simple but impactful strategies that can be used to end and/or minimise violence against women (UN Women, 2020). These strategies are briefly discussed below.

***1. Listen to survivors* –** A victim of violence can break the chain of abuse, by telling their story to others. When speaking to a victim, it is important to remember that the individual age, race, sexuality, and background are relevant and that the full responsibility of the assault lies with the perpetrator. In recent times, more and more victims of violence have been speaking out about their situation in an attempt to ensure that their perpetrators get the necessary justice.

***2. Teach and learn from the next generation* –** It is our responsibility to set good examples of respect and harmony between different genders to the younger generations, as what we teach them shapes the way they think about certain concepts. By educating children and providing them with the right information about human rights, violence between different genders can be minimised or even prevented in the future. Conversations about equality, gender roles, traditions, and assigned characteristics to men and women are only some of the topics which should be addressed when teaching a younger generation about right and wrong. Also, point out stereotypes encountered by children and try to encourage a culture of acceptance among them.

***3. Provide response services to victims* -** Shelters, safe havens, helplines, trauma support, and counselling are crucial when supporting victims and survivors of GBV. These services need to be available at all times for individuals in need, even during this pandemic period.

***4. Understand the concept of consent* –** consent between individuals is essential in any setting. The UN Women state that it is important to adopt an enthusiastic approach to consent in all aspects of your life, and not just in an intimate setting. Perpetrators normally use the concept of consent as an attempt to blur sexual boundaries in an attempt to place the blame on their victims, exempting themselves from their sexual crimes.

5. Observe signs of abuse– Many types of abuse exist that can have major emotional and physical effects on victims. If a victim suspects that they are being abused they should take the first step and seek help, as help is available. If an individual suspects that someone close to them is a victim of abuse they should look for warning signs and seek ways in which they can help and support these victims.

6. Speak up and increase awareness – The only way to increase awareness on this topic is to speak up and make your voice heard. GBV violates human rights and has continued for decades. There are various human rights organisations that one can form part of to stand up for women's rights and GBV. Awareness can also be created on different social media platforms.

7. Stand up against normalised rape culture – A rape culture in a society or community allows sexual violence to be justified and normalised and originates from gender attitudes, norms, and inequalities about sexuality and gender. It is our responsibility to continuously examine our beliefs and behaviours for views that allow a culture of rape to continue.

8. Fund organisations that support women and victims of violence - Donate to local campaigns and organisations that support and empower women and survivors and promote acceptance of different sexualities and gender identities.

9. Accountability – Stand up against violence by calling out violence when you see it taking place.

10. Understand GBV and its related data – The concept and issue of GBV need to be fully understood to effectively address the matter. Relevant data needs to be collected to successfully implement prevention measures. The UN Women urge governments to invest time and resources in collecting GBV data, especially, in recent times.

Various intervention strategies within the South African context are implemented and used to try and minimise and prevent GBV in the country. An Emergency response action plan has been developed and approved by the South African parliament and aims to implement the following key interventions in due course (Interim Steering Committee, 2020):

- Responding to and supporting GBV victims and survivors.
- Broadening the access that victims and survivors have to justice.
- Increasing awareness of GBV through prevention campaigns to change social behaviour and norms.
- Promoting and increasing GBV perpetrator accountability and increasing the number of current prevention strategies and attempts.
- Creating more opportunities for women in communities, society, and the economy.

The Interim GBV and Femicide Steering Committee have also created a GBV and Femicide National Strategic Plan to address GBV issues in South Africa. This plan provides a coherent, multi-sectoral and strategic framework to guide GBV and Femicide national response attempts in a coordinated manner (Interim Steering Committee, 2020).

The GBV Sub Sector Working Group - Nigeria (2017) developed a GBV sub-sector humanitarian strategy for GBV response, mitigation and prevention in Nigeria. This strategy emphasises key GBV strategic areas and its associated intervention strategies. This strategy aims to maximise the impact of GBV and is briefly discussed in Table 3. This strategy hopes to enhance the safety of and protection provided to all vulnerable individuals who are frequently exposed to GBV, to enhance society's knowledge and awareness on the topic of GBV, and finally to provide individuals with a strengthened and improved framework for the effective coordination of GBV multi-sectoral responses and prevention attempts.

Table 3: Humanitarian GBV response, mitigation and prevention strategy

Strategic objective	***Key priority***
Increased access to well-coordinated and comprehensive GBV response services	- Material assistance provision (including rehabilitation packages, material support in emergencies and distribution of dignity kits). - Providing medical and healthcare services to GBV victims and survivors. - Providing support to GBV survivors and victims. - Providing mental healthcare, counselling and support to victims and survivors of GBV. - Providing legal and security services to individuals who are at risk of GBV.
Improve GBV prevention systems and increase awareness of GBV	- Providing livelihood support and vocational skills to GBV at-risk individuals. - Organising activities for GBV training. - Creating initiatives that raise awareness and facilitate response and prevention of GBV. Facilitate community protection systems and mechanisms for GBV.
Recognise GBV in humanitarian prevention and response attempts, and keep GBV statistics and data accurate and updated	- Advocacy intervention support with key policymakers. - Management of GBV information and data. - Coordinating GBV response and prevention attempts. - Mainstreaming GBV.

2.1.3. GBV as a Complex Social Problem

Homer-Dixon (2011) states that a shift has to be made from seeing the world as consisting mainly of simple machines to seeing it as consisting of the most complex systems. In the past it was believed that complex systems could be easily analysed and broken down into parts, to precisely understand the interacting relationships within the system. As a result, it was believed that the behaviour of these systems could often be correctly predicted and precisely managed. But, we live in a world of increasingly complex systems, and we have to manage and live with the magnitude of these complex systems all the time.

To classify GBV as a complex social system, one must understand the characteristics of a social system, what the phrase "complex system" entails, and to distinguish between different types of systems, specifically complex and complicated systems.

Various characteristics exist for social systems and are described by Forrester (1971) in an article titled "Counterintuitive Behaviour of Social Systems". The characteristics described in this article include that social systems are naturally insensitive and resistant to policy changes that individuals select and implement in an attempt to change the system behaviour, these systems have very few areas where changes can be made to positively influence the system structure and behaviour and that a fundamental conflict usually exists in social systems between short-term policy changes and long-term policy changes.

A complex system is defined as a system that has two or more parts that dynamically interact to function as one whole (Serrat, 2017). Complex systems have many components with a high degree of connectivity and interaction between them and are often difficult to bound (Homer-Dixon, 2011). Properties presented by complex systems cannot be determined from that of their parts, as these parts are interconnected and intricate. According to Serrat (2017), complex systems are set apart from other systems by the following characteristics:

i. Parts are interconnected and dependent on one another.
ii. Constant movement and responses among parts.
iii. Continued existence and operation of the system due to the system's ability to adapt to different situations.
iv. Increased system complexity over time.
v. Self-organisation, by which the system can take on different forms.

The distinction between complex and complicated systems is often overlooked, which makes classifying modern social systems as complex systems difficult (Poli, 2013). According to Poli (2013) the difference between these two systems is not one of degree but of type. For example, a complex system is not more complex than a regular complicated system (difference of degree), but it is a completely different type of system (difference of type). The distinction made between a complex and a complicated system is defined in Table 4.

Table 4: Difference between complex and complicated systems

Complicated system	***Complex system***
Causes can be determined individually	Causes cannot easily be distinguished or determined individually (as causes are connected and interact in large networks)
Causes can be individually addressed	Causes must be addressed as an interconnected system
A system can be controlled	A system cannot be controlled
Permanent solutions can be used to solve the problems that emerge from the system	Problems emerging from this system cannot be permanently solved and must be managed systematically

Miles (2009) states that one must appreciate the dynamically complex relationships that exist within a complex system that need to be cultivated and understood in more detail than just a simplistic linear thinking approach. GBV inherits all the characteristics of complex systems, as defined in this section, and should therefore be treated as a complex social system.

2.1.4. Quantifying complexity in systems

Lucas (2000) defines four types of complexity that a system can embody, namely static, dynamic, evolving, and self-organising complexity.

Some of the main objectives of quantifying complexity in a system include explaining new and emergent structures within a system, to measure the relative degree of complexity within a system, to provide various methods to control the complexity of a system and to generate effective problem-solving models for a system.

Complexity science is one approach that can be used when working with complex systems. It deals with systems that are dynamically complex and multi-dimensional, and where system behaviour is unpredictable due to many interconnected relationships and parts. This theory states that systems components that critically interact and self-organise to create evolving

structures that can potentially exhibit a hierarchy of new and emergent properties in a system. Quantification approaches used in complexity theory originate from a diverse and multidisciplinary field and are based on various mathematical techniques. Techniques include Spider diagrams, Linkert scales, Algorithmic information theory, Game theory, Time series analysis and Fuzzy logic.

- ***Spider diagrams:*** This is a way of simplifying decision-making in systems and serves as a means of facilitating increased learning into complex systems, by comparing a variety of system metrics. These metrics are measured on a scale of one to 100 (or any other suitable range) and plotted on an axis. Spider diagrams aid in developing relationships between possible associative and causal pathways and evidence-informed or data-based concepts.
- ***Algorithmic information theory:*** This technique is used to describe complexity in systems by using the shortest possible computer programs. The length that this program runs is a means of measuring and quantifying complexity.
- ***Game theory***: This theory illustrates interactions in a system based on decisions made and the advantages associated with them. This theory quantifies system decisions at an individual level.
- ***Time series analysis:*** This technique is used to identify any regularities that exist in the behaviour of systems over time, trying to quantify various system attractors. The limitation of this technique is that a lot of data is needed to perform a time series analysis. An advantage of this type of analysis can be given to a system's behaviour.
- ***Fuzzy logic:*** This technique provides a means of quantifying interacting variables in non-linear systems. Fuzzy logic is appropriate to use and helpful in situations where the complexity of a system is very complex and difficult to fully understand, or in situations where a quick and reliable solution to a problem is required (Ross, 2005).

2.1.5. Previous research on GBV

In recent times GBV research has become more prevalent with enormous research has done in this field. Three studies are used in this subsection to illustrate some of the research done in this field. These studies were conducted in different environments, at different time periods, and for different reasons.

2.1.5.1. Study 1: The Prevalence of Gender-Based Violence against Women in South Africa: A Call for Action

Enaifoghe et al. (2021) recently published a study in the African Journal of Gender, Society, and Development where they discussed GBV in South Africa and the impact that it has had on individuals in recent times. This study argues that the prevalence rates of GBV in South Africa are a widespread and intense problem that has an impact on nearly every aspect of a victim's life. In this study, the need for intervention in preventing GBV in South Africa is emphasised. A summary of this study is provided.

The study was performed by *Andrew Enaifoghe* (Public Administration and Governance at the University of Zululand), *Melita Dlelana* (Ethics: Research and Innovation at the University of Zululand), *Durokifa Anuoluwapo Abosede* (School of Public Management, Governance and Public Policy at the University of Johannesburg) and *Nomaswazi P. Dlamini* (Department of Politics and International Studies at the University of Zululand) (Enaifoghe et al., 2021).

This study urges the South African government to take vital actions to effectively address GBV in the country. The implementation of an improved strategic plan was recommended by this study, having recognised what impact GBV has not only on its victims but on the general society as well. The current Policy Gap that exists in addressing GBV in South Africa was accessed, and the role that media plays in reporting violence was analysed.

This study was published as part of the journal (Volume 10 Number 1, Pp 121-150) in March 2021. The approach for this study is described below.

- A qualitative approach, based on a variety of relevant literature sources (ie. Articles, internet sources, books, and reports), was used for this study by utilising a content data analysis method. This method allows researchers to make sense of and study written documents that are available and easily accessible in private and public domains.
- Relevance of the documents used in this study is measured based on the significance they have in the study. Preliminary data was collected via secondary sources.
- The search for relevant literature was streamlined between 2010 and 2020. However, exceptions were made to years before 2014 based on the information obtained and its relevance to the study.
- The study used different literature relevant to the subject and analysed this literature based on its relevance and content to the study.

2.1.5.2. Study 2: WHO Multi-country Study on Women's Health and Domestic Violence against Women (Initial results on prevalence, health outcomes, and women's responses)

This study was performed in 2005 by *Claudia García-Moreno* (Coordinator for the Department of Gender, Women, and Health at the WHO and the coordinator of this study), *Henrica AFM Jansen* (Epidemiologist), *Charlotte Watts* (Senior Lecturer in the Department of Public Health and Policy at the London School of Hygiene and Tropical Medicine), *Mary Carroll Ellsberg* (Senior Adviser at PATH for Gender, Violence, and Human Rights) and *Lori Heise* (Director at PATH for the Global Campaign for Microbicides, Research fellow at the London School of Hygiene and Tropical Medicine) (García-Moreno et al., 2005).

In this report, data collected from more than 24 000 women in ten different countries were analysed. These individuals represent diverse cultural and geographical backgrounds. This study was specifically designed to:

- accurately estimate the violence prevalence rates against women (i.e. sexual, emotional, and physical violence), particularly violence by an intimate partner(s).
- analyse partner violence with associated health outcomes.
- identifying factors that can increase or decrease a women's risk of partner violence
- documenting different services and strategies that can be used by women to cope with intimate partner violence

This study started by clearly defining and measuring different forms of violence via different criteria such as the type of act or the type of relationship that exists between perpetrator and victim. Next formative research was performed by using key informants, conducting interviews and discussions with survivors. Finally, questionnaires were developed and structured to maximise disclosure. These questionnaires were also translated for each of the countries taking part in this study.

Some of the main findings in this study include: *(Note that these are not the only findings discussed in the study and that only a few have been provided below)*

- The prevalence rate of physical violence (experienced by a woman who has had a partner in her lifetime) by an intimate partner ranges between 13% and 61%, with the majority falling between 23% and 49%.

- Between 6% and 59% of individuals have experienced sexual IPV.
- 19% and 76% of women have experienced physical or sexual violence from 15 years of age.
- Women experiencing physical and sexual partner violence had poor health compared to women not exposed to this form of violence.
- Etc.

The WHO provides a detailed list of recommendations, based on findings from the study, that can be implemented by local and national governments in collaboration with other organisations like NGOs, to ensure the safety and well-being of their citizens. These recommendations are grouped into seven main themes namely, strengthening action and national commitment in this field, promoting primary prevention and prevention strategies, educational sector involvement, strengthening the response of the health sector, providing support to women living with violence or who experience violence, sensitising the justice system for criminal behaviour and promoting further research into this topic.

Future work that can be explored in this field includes analysing violence risk profiles, specifically looking at the duration of a relationship with a violent partner, determining if risk factors are specific to a certain context or not, and clearly and accurately defining the term emotional abuse and its prevalence, conducting an in-depth and a thorough analysis of the relationship that exists between violence, health and different patterns of women's response to violence, and violent behaviour, etc.

2.1.5.3. Study 3: Gender-Based Violence Against Adolescent and Young Adult Women in Low- and Middle-Income Countries

This study was performed by Decker et al. (2015) as GBV is an ongoing human right and global health issue for individuals and society at large. Young adolescent women are considered to be most at risk for GBV, regardless of their age, race, religion, etc. Indicators of GBV and intimate partner violence are evident in low and middle-income countries across the world, especially among young girls.

The method followed in this study entailed generating national prevalence estimates in these low and middle-income countries among adolescents and young adults. Adolescents are classified as 15 to 19 old, and young adults as 20 to 24 years old. A meta-analysis was performed to provide comparisons across nations and establish regional estimates in these

countries. These were compared against the previous years' prevalence rates among adolescents and young women.

Results from the study are as follows:

- approximately 28%-29% of adolescents have reported that they have experienced IPV in their lifetime. These findings were seen mostly in Eastern and Southern African regions.
- Young adult women were found to be at the highest risk for IPV (when compared to adult women over the age of 24 years).
- Forced sexual interaction was found to be the highest and most prevalent in Eastern and Southern African regions, estimated at approximately 12% overall.

This study concluded that GBV is common among both adolescent girls and young adult women in these countries. This study argues that GBV poses a unique risk to the youth in different nations. Findings from this study provide direction for GBV prevention efforts and serve as a basis for future research and clarifying GBV determinants.

The implications and contributions of this study are that there is an important cross-national variation that burdens and disproportionately affects GBV experienced by adolescents and young adults (specifically in intimate partner violence and forced sexual interaction).

It is clear from these three studies that the need for practical, concrete and effective complexity modelling approaches to complex social systems is growing (Serrat, 2017). This is as complex social systems are considered to be a major concern globally. One such approach is that of holism. Holism assumes that system parts/variables can only be described by their position and meaning within the system as a whole. This forms the basis for the perception of the reality of complex systems. But how can we fully understand what is meant by the system as a whole? The answer to this question lies in the concept of systems thinking.

2.2. Systems Thinking

A complex system consists of various interconnected entities that are interdependent and dynamic. Therefore, it is essential to first make sense of the relationships between system entities before addressing the problem. This is reached by creating a comprehensive picture of the whole system. Systems thinking (ST) is described as a holistic approach to analyse how a system's constituent parts are interrelated and how these parts work within the context of a

larger system over time. ST can be used to address specific problems or systems holistically. ST provides a framework to accurately represent complex problems as systematic wholes (Anderson and Johnson, 1997).

Anderson and Johnson (1997) refer to ST as a language that enables individuals to enhance and improve their understanding of various problems and allows individuals to better communicate about the inter-dependencies, complexities and dynamic behaviour of systems. Behavioural and emerging patterns of a system over time can be identified with ST, which plays a vital role in problem-solving. It includes various methods, tools, and ideas that consider the relationships and interactions among entities in the system.

2.2.1. Systems thinking tools

ST is premised on the concept of holistic thinking. Holistic thinking is described as the ability to see and perceive things as a whole rather than as a single entity. It allows one to understand, predict and analyse the various types of relationships that exist between elements in a complex system, by sensing the systems' large-scale patterns. ST tools can be divided into different categories. These tools can be used individually or in conjunction with one another to gain improved insight into a system's dynamic behaviour. These tools are discussed in Table 5 (Kim, 2021).

Table 5: Systems Thinking (ST) tools

ST Tool	***Description***
ST Brainstorming tools	
Ishikawa Diagram	- Alternatively named a "fishbone" diagram. - used for the cause and effect analysis of a system. - serves as a means of capturing primary (direct) and secondary (indirect) causes of a problem.
Double-Q Diagram	- Structures and created using brainstorming. - based on the Ishikawa Diagram. - serves as a structured way to represent and capture ideas and thoughts of a system or problem. - differentiates between quantitative (hard) system variables and qualitative (soft) system variables.
Dynamic ST Tools	
Causal Loop Diagram	- Captures and illustrates system behaviour and how variables interrelate and interact.

ST Tool	*Description*
	- depicts balancing and reinforcing processes that indicate how a small change in one variable can have a major impact on system behaviour and cause changes to other variables in the system. - Limitations: if insufficient time and effort are put into developing these diagrams they can be incomplete, overly simplistic or not representative of reality.
Behaviour over time Graphs	- visually represents the behaviour of system variables over time. - historic, current and future data can be used when creating these graphs to show system behaviour. - provides insight into system entities and the system as a whole.
System archetypes	- Allows one to recognise and effectively manage common patterns in system behaviour. - allows one to identify key leverage points within the system where intervention strategies can be implemented in an attempt to change the systems' behaviour. - Types of archetypes include Drifting goal, Fixes that fail, Escalation, Limits of success, Growth and under-investment, Success to the successful, Shifting the burden and Tragedy of the commons.
Structural ST Tools	
Policy structure Diagrams	- Conceptually maps out the decision-making processes that are embedded in certain systems or organisations. - Emphasis is placed on factors that can be used to develop generic system structures and which are weighted for each different system decision that is made.
Graphical function Diagrams	- Clarifies non-linear relationships that exist between two or more system variables. - depicts how one system variable affects another variable. - the relationship between two system variables is plotted over a relevant range of values.

2.2.2. Systems thinking modelling approach

Cavana and Maani (2000) developed an ST and modelling methodology in which they combine ST and systems dynamics tools to solve complex problems. Figure 3 provides a broad overview of this methodology. The steps required for executing the first two phases of this methodology are discussed in this section. Modelling steps required for phases three to five are discussed in Section 2.3.2.

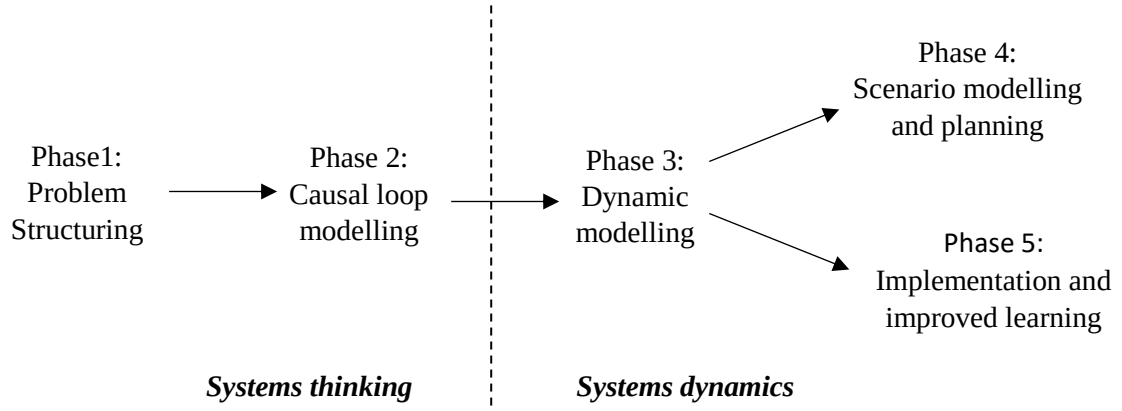

Figure 3: Systems Thinking and Modelling methodology phases

Phase 1: Problem structuring *(most approaches to problem-solving use this as a starting point)*

- Identify the problem environment/area.
- Identify concerning policy issues.
- Establish system objectives from multiple perspectives.
- Collect primary data and information.

Phase 2: Causal loop modelling

- Identify key system variables.
- Use key system variables to develop behaviour over time graphs.
- Represent relationship among key system variables by developing one or more causal loop diagram(s) for the system.
- Discuss system behaviour from these relationships.
- Describe causal patterns in system behaviour by identifying and developing system archetypes.
- Identify leverage points where interventions can be implemented.
- Develop suitable and effective intervention strategies.

2.3. System Dynamics

System Dynamics (SD) is a modelling approach used to discover, understand and represent the non-linear behaviour of complex systems and feedback processes that exist within a system over time. Complex system dynamics and behaviour often emerges from interactions and feedback processes among system components (Sterman, 2000).

SD was founded at MIT in 1957 by Jay Forrester. It is defined as a method where simulation can be used to aid in solving real-world complex problems by describing the relationships that

exist among system variables (Maryani et al., 2015). Forrester (1994) states that SD is a unique and effective modelling tool due to its ability to accurately represent the real world. They also argue that SD easily accepts any complex, non-linear feedback structures associated with social or physical problems. Fuchs (2006) identifies SD as an advantageous modelling approach as it is simple and easy to use. Dynamic complexity in systems arises due to various factors and is seen when systems are ever-changing and adaptive, non-linear and tightly coupled, history-dependent and characterised by trade-offs, when self-organisation exists within the system, and where a system is policy resistant and counterintuitive (Sterman, 2001).

2.3.1. System dynamics tools and techniques

To determine the dynamics of a system, SD tools such as stock and flow diagrams, time delays, and table functions can be utilised.

Stock and flow diagrams (or called Level and rate diagrams) are used to represent a more detailed structure of the system, than evident on a causal loop diagram. These diagrams are often used as the first step when developing simulation models, as they aid in defining different types of system variables that impact system behaviour. Stocks (or levels) are key for generating system behaviour, while flows (or rates) influence stocks and cause them to change.

Time delay in systems dynamics is crucial to the system, as it represents the elapsed time between a system change taking place in one part of the system, and the change is reflected in another part of the system (Roy, 2000). A time delay is a change in the effect of a system input on the dynamic response of the system's output. Delays play an important role when modelling systems and need to be correctly represented to depict real system behaviour.

Table functions are used in situations where a non-linear relationship exists among two different system variables. Table functions are often preferred when developing models for complex systems, as they are easier to use, visualise and interpret than complex modelling equations.

2.3.2. System dynamics modelling approaches

SD can be used as a qualitative or quantitative method for exploring and analysing complex systems (Kunc, 2017). A qualitative SD approach's main objective is to identify feedback loops that exist within a system. This is done by developing causal loop diagrams (CLD) for the system under consideration. For quantitative SD the main objective lies in creating and

testing a hypothesis that relates to the driving structures within the system variable. Qualitative and quantitative SD modelling steps as described by Kunc (2017) are described below.

2.3.2.1. Qualitative SD modelling approach

- ***Objective:*** To understand the current feedback structures of a system.
- ***Modelling process steps:***

  (1) Identify the causality link between system variables

  (2) Allocate polarities to the relationships between related system variables.

  - Positive polarities are allocated if a change in the same direction is evident
  - Negative polarities are allocated to depict change in the opposite direction

  (3) connect system entities in a cause and effect chain to form/establish feedback processes within the system. Two types of feedback processes within systems include reinforcing and balancing processes.

- ***Outputs:*** Increased learning of system structure, changed system perspectives and future policy/response agreements.

2.3.2.2. Quantitative SD modelling approach

- ***Objective:*** To test a hypothesis related to the structure(s) that drives the reference mode of a system variable.
- ***Modelling process steps:***

  (1) Define the system boundary by identifying the behaviour of key system variables over time.

  (2) Use stock and flow diagrams to describe system structures and behaviour.

  (3) Formulate the model.

  (4) Perform extensive and thorough model testing.

  (5) Designing experimentation procedures and policies for the model.

- ***Outputs:*** Time series data that indicates how system variables perform over time and increased learning of the systems' dynamic behaviour.

Returning to the methodology discussed in Section 2.2.2 and developed by Cavana and Maani (2000), phases three to five apply to the concept of SD. These phases are performed after completing phases one and two of this methodology. The modelling steps required in these phases are listed below.

Phase 3: Dynamic modelling

- Create a high-level picture of the key system variables and issues within the system to create a potential model.
- Define and create stock and flow diagrams for this model.
- Collect all necessary data.
- Simulation model development, by using both the causal loop diagram(s) and stock and flow diagram(s) developed in previous steps (computer software and packages such as Vensim, Powersim, Stella etc. can be used for this step).
- Simulate and run the model over a specified time.
- Produce model outputs in the form of graphs and tables and compare this with historical trends.
- Verify all parameters, equations and defined boundaries of the model.
- Perform sensitivity analysis.
- Design policies for the model and test this to see if it leads to any system improvements.
- Strategy development and testing.

Phase 4: Scenario planning and modelling

- Development of general scope, external environment boundaries and time frames for different scenarios.
- Identification of uncertainties and key drivers of change within the system.
- Construction of forced model scenarios.
- Simulating these scenarios.
- Evaluate model performance for each developed scenario.

Phase 5: Implementation and organisational learning

- Documentation and presentation.
- Communication of newly found/gained insights, results and interventions to appropriate parties.
- Model micro world, learning lab design and development.
- Facilitate improved learning of the system.

Rodriguez-Ulloa and Paucar-Caceres (2005) defined a Soft Systems Dynamics Methodology (SSDM) as capable of serving as an intervention approach when faced with complex social situations. This combined methodology emerges from an SD and a basic soft systems methodology. The main contribution of this methodology is that it provides a general step-wise

framework, to allow individuals and decision-makers to model the real world and to comprehend and grasp a complex problematic situation. Steps in this methodology include, unstructured and structured situations, problem-oriented definitions, problem situation dynamic model development, determining the feasibility and changes required, dynamic solution model development, solving the problem, implementing changes and improved learning.

One of SD's main strengths lies in the fact that it is able to rigorously and accurately test and reproduce the complex behaviour of a real system. To develop better solutions for complex social problems new methods must be used to represent the complex evolving behaviour of these problems. These methods must be capable of handling the multilevel dependencies of society and communities and the feedback relationships within the system environment shape the solution strategies. An example of this is the innovative approach that SD provides when modelling complex social problems and community interactions.

2.3.3. Previous research using System Dynamics

When researching the topic of SDs it is important to consider previous research and work done in this field, especially work done on social problems and/or systems. Some examples of social systems/problems include safety, healthcare, accessible education, and any other area that serves to be beneficial to society at large. Systems dynamics research is often used to address complex social problems, as it provides insight into the issue and aids in long-term policymaking. Previous research studies show how SD can be used to effectively and accurately capture elements of dynamically complex systems and provide an improved understanding of a systems behaviour over time.

In an article written by Forrester (1971), the counterintuitive behaviour of social systems is discussed. He argues that government policies and intervention programs often fail or have an undesired result, as we do not fully understand the behaviour and nature of social systems. The rest of this section presents various research done for social problems and to address the diverse social challenges that humanity faces, using SD as its main methodology.

2.3.3.1. Study 1: Counterintuitive Behaviour of Social Systems

The purpose of this paper written by Forrester (1971) is to make readers cautious about their continuous dependence on past approaches to address social problems. This paper suggests a new approach to addressing social problems that combines the strength of both computers and

human minds today. This approach can lead to an improved understanding of social systems and aid in developing more effective future policies for guiding social systems.

This paper states that until recently there has been no easy way to accurately and effectively estimate social system behaviour except using discussion, contemplation, guesswork, and or argument. This new approach to modelling social system dynamics differs from that of common government and social science practice. With common practices, data availability and information are scarce and or lacking. The data for such modelling attempts must be collected and confidently interpreted for the model to be accurate and effective.

Forrester however argues that the problem does not lie in the shortage of and scarcity of data and information, but in the way that we perceive and interpret this data. This new system dynamic approach starts off with general, but sufficient, information and concepts that people already have to their avail. This is then used as input to the computer model to show system consequences and their perceived parts.

2.3.3.2. Study 2: System Dynamics Modelling for Public Health: Background and Opportunities

Homer and Hirsch (2006) performed this study and applied SD modelling to the field of public health, as it is an area that continuously struggles with challenges such as meeting its primary objective. They believe that a SD modelling methodology can be used to effectively address the many challenges faced by the health sector due to the dynamic complexity that exists in public health.

The methodology performed in this study involved the development of causal diagrams and computer simulations that are policy-oriented and unique to different problem settings. This paper presents two examples of social systems within the healthcare environment including using SD for chronic disease prevention and developing more complete and accurate models for the public healthcare field. Case studies were used to explain these models.

2.3.3.3. Study 3: Sequence and Timing of Three Community Interventions to Domestic Violence

This study was conducted by Pieter S. Hovmand and David N. Ford in 2009 (Hovmand and Ford, 2009), and responds to the issue of DV with a SD methodology to model community intervention. In this paper, a model of DV cases in the criminal justice response system is

presented. This model utilises simulation to accurately evaluate the impact of the interventions on different system-level outcomes. The interventions strategies include victim defence, changes to the level of cooperation, and mandatory arrest of perpetrators. System-level outcomes in this study include increasing the safety of DV victims and improving the accountability of DV offenders.

SD was used to address the stated research questions of the study and emphasised the role that feedback relationships play in understanding how systems behave and evolve. These feedback relationships were defined by various differential equations that represent changes in system behaviour and function over time.

The approach started with data collection for developing the model. Data was primarily obtained from a previous study in a rural community. This data also included a database of violence against women, which included information such as the victim's and suspected perpetrator's name, the relationship type that exists between victim and perpetrator, and both individuals' demographics, to name a few.

Next, the model was formulated and developed on Vensim and places the focus on the changing relationship between intimate partners transitioning between different risk categories of the arrest. This was tested to see if the structure of the model and that of the real system were similar. It was also tested for consistency, similarity, and reasonableness of system behaviour. Equations used in the model were also reviewed.

The results from this study illustrate how even the simplest of systems can generate dynamically complex patterns of behaviour. The study shows that the response of a system to different interventions differs after the implementation of mandatory perpetrator arrest, as these arrests change the state and ultimately the behaviour of the system. The results from this study also show how problematic the use of a single outcome indicator can be to the system.

2.3.3.4. Study 4: System dynamics applications to injury and violence prevention: a systematic review

This study was performed by *Rebecca B. Naumann* (PhD qualification, Department of Epidemiology and Injury Prevention Research Center at the University of North Carolina), *Anna E. Austin* (MPH qualification, Department of Maternal and Child Health and Injury Prevention Research Center at the University of North Carolina), *Laura Sheble* (PhD qualification, School of Information Sciences at Wayne State University and in the Duke

Network Analysis Center, Social Science Research Institute at Duke University) and *Kristen Hassmiller Lich* (PhD qualification, Department of Health Policy and Management at the University of North Carolina) and published on 25 April 2019 (Naumann et al., 2019).

This review was performed to summarise different SD applications in the field of injury prevention. This review highlighted various opportunities where SD can be used to effectively contribute to injury prevention research in the future. The search was conducted as follows:

- Identification of all SD modelling applications to injury outcomes in various peer-reviewed literature and studies between January 1958 and June 2018.
- Relevant studies were identified and obtained through Web of Science and PubMed.
- Search strategies included: SD or related terms were used when searching for keywords, reviewing all articles accepted for SD conferences and published in the *System Dynamics Review*, and reviewing all articles that cite foundational publications in the field of SD.
- Restricting search results only to health-related applications.

Inclusion and exclusion criteria for this review included:

- Include articles if they are injury-related and when actual SD applications are applied to the problem in different contexts.
- Exclude articles if they only talked about the dynamic nature of a problem, only recommended that SD methods should be used in future work, and where no form of qualitative or quantitative SD modelling approach was used.

2.3.3.5. Study 5: Victims arrested for domestic violence: unintended consequences of arrest policies

This study was performed by Peter S. Hovmand, David N. Ford, Ingrid Floma, and Stavroula Kyriakakisa (Hovmand et al., 2009). This paper presents an SD model to effectively deal with victim arrests. This study was conducted as DV continues to be a major social problem in many societies.

This model is used to describe a community where a compulsory arrest policy is implemented and the effect that this has on victim arrests. Modellers gained an improved understanding of system complexity and behaviour. A single case study research method was utilised in this

study. Key informants were interviewed before model development to verify numerical data of the model and to assess the model structure. Model structures were developed and tested and assumed that deterrence in the system affects new cases that enter the system.

Results from this study show the inherent complexities that exist in the relationship between victim arrests and mandatory arrest policies. The model analysis performed in this study highlights the temporary nature of social mechanisms and shows how stock–flow distinction and feedback mechanisms are crucial in their response to policy changes. This study also emphasises the importance of cooperation in domestic violence responses in the community.

2.4. Prioritisation and Decision Science Methodologies

Prioritisation methodologies are developed to help determine which tasks/activities in a system or process require priority and more attention than the secondary tasks/activities. It also allows decision-makers to spend less of their time and effort to get the best possible results. The term decision science is used to describe various quantitative techniques that can be used for decision-making at various levels in the problem environment. It provides a unique framework that can be used for understanding public and or social problems, and for making improved policy decisions that will address those problems. A variety of tools can be utilised during both prioritisation and decision-making as discussed in the subsections that follow.

2.4.1. Imperative structural modelling (ISM)

Interpretive structural modelling (ISM) methodology is well known and used to identify different relationships between variables of a defined problem (Attri et al., 2013). Research into this field has been done to represent different interrelationships between elements related to a problem. The model illustrates the complex structure of a problem using a designed pattern and provides insight into the collective understandings of problem relationships.

Characteristics of ISM include:

- Structured based on mutual relationships.
- A complex set of elements determines the overall structure.
- Relationships and structures are portrayed on a digraph model.
- Provides direction and order on the complexity of relationships between system elements.

2.4.2. Hybrid Structural Interaction Matrix (HSIM)

The Hybrid structural interaction matrix (HSIM) is a new prioritisation approach developed by Ayomoh and Oke in 2006. This prioritisation methodology uses a root cause approach and reduces bias commonly found in current prioritisation methodologies (Ayomoh and Oke, 2006). They describe the HSIM approach as a unique problem-solving tool that can be used to prioritise system factors through the concept of subordination. The HSIM methodology contains and integrates features of Structural Interaction Matrix (SIM), Goal Programming (GP) and Hierarchical Tree Structure Diagrams (HTSD). These concepts are not discussed in this literature review. The HSIM approach, unlike SIM or HTSD, allows for further quantitative numerical analysis of system factors by integrating a weighting factor into its methodology (Ayomoh et al., 2008).

2.4.3. Analytical hierarchy process

The Analytical Hierarchy Process (AHP) is a method used for analysing and organising complex decisions and scenarios. This decision-making method is effective in complex environments consisting of many variables (to be considered when selecting and prioritising alternatives) and provides a framework in which the decision-making process in these environments can be quantified.

AHP is one of the most widely used multi-criteria decision-making methods and is concerned with the rating and aggregation of alternatives (Ramanathan, 2004). AHP's popularity lies in its flexibility, simplicity, intuitive appeal, and its ability to combine different quantitative and qualitative criteria in one decision framework.

The AHP method is most useful when looking to determine various decisions in high stake complex problems or systems. It is unique as it quantifies criteria that are difficult normally difficult to measure with hard numbers. AHP enables decision-makers to find alternatives that best guide their understanding of the problem.

The AHP method starts with decomposing the problem or system into a hierarchy of different criteria, that allows for problem analysis and comparison to be executed independently and effectively (Vargas, 2010). After this, pair-wise comparison of the different criteria is done to assess alternatives systematically. This empirical pair-wise comparison is transformed into numerical values that can be compared and processed further. The main distinctive feature of

this method compared to other decision-making methodologies is AHP's capability of transforming empirical data into numerical values.

Once all relevant comparisons between criteria have been made, and weights quantitatively assigned, the probability of the alternatives can be calculated. The higher this calculated probability, the more likely that the alternative will satisfy the final system goal.

2.4.4. Multiple Criteria Decision Analysis (MCDA)

Multiple Criteria Decision Analysis (MDCA) is a decision-making technique that allows one to evaluate various alternatives against a set of predefined criteria. This technique starts with specifying the problem context and identifying available alternatives. Objectives are then confirmed and different criteria are selected to represent key variables. Each criterion is then measured to find its relative importance and to calculate this importance measure utilising averaging of weighting techniques.

There are various advantages when using MDCA for decision making namely, that it is explicit and open and that the selected criteria can be easily adjusted, that it provides insight into value judgements, that various different factors can be compared against each other and that it serves as a means of communication during decision making (Toolshero, 2021).

2.4.5. Decision-making trees

Decision-making tree diagrams are useful when the outcome of a decision is unclear. This type of diagram provides a visual aid when analysing various phases and unclear outcomes of a proposed. Decision-making trees are flexible and clarify different choices, objectives, and risks involved in decision-making. These diagrams are effective when communicating process complexity and place their focus on data and probabilities, rather than bias and emotion (Cravit, 2021). Decision trees prove to be an effective method in decision-making situations (Mind Tools, 2021) as they:

- Clarify the problem and lay it out in such a way that all alternative options can be challenged.
- Allows for a full analysis of a decision and its consequences to be made.
- Provides a framework that can be used to quantify outcome values and shows the probability of achieving each outcome.
- Allows for better decision-making based on existing information and estimates.

2.5. Barometer Application

A Barometer is a measurement tool that can be used in many different environments. Engineering-based tools that can be used to create a barometer for a complex system and its entities are described in the paragraphs that follow.

2.5.1. Interactive dashboard design

An interactive dashboard is described as a data management tool that enables individuals to analyse, track, monitor, and visually display information, Key Performance Indicators (KIPs) and metrics. These dashboards also allow its users to interact with this information and data, allowing them to make more informed decisions. Interactive dashboards provide users with real-time insight into various data metrics by enabling end-users to interact directly with this data. This allows them to develop an improved and deeper understanding of a problem and its environment.

Interactive dashboards can be used as visualisation tools to make sense of complex data and systems. Interactive dashboards allow their users to easily display, navigate and select data. These dashboards are often used as part of (or as output to) the data analysis process. There is different type of interactive dashboards that can be used to visualise data according to Hayward (2021) namely, Operational dashboards (if the goal is to visualise what the current state of a system or problem is), Strategic dashboards (If the goal is to illustrate the performance of a systems' KPIs) and Analytical dashboards (if the goal is to process certain data sets to identify trends or patterns in the data).

Existing software packages and platforms, like Excel, can be used to build an interactive dashboard. By using an existing platform, the dashboard development process becomes simple and can easily be applied to or replicated for other data. Dashboard designs in Excel are simplistic, easy to build, consists of various features, are freely available, and can be easily shared with others.

Some characteristics of an interactive dashboard includes (Barillas, 2017):

- It aligns with goals and objectives
- Places numbers and data into context
- Keeps data current
- Uses visuals to depict data

- Tells a story of the data and or system
- Provides a logical layout for analysis

Dashboards and basic reporting principles have some similarities including that both presents data and consolidate multiple system metrics. There are however many differences between the two including that dashboards are interactive and data used in them can be easily updated while reports are static and that dashboards monitor the performance of the system goals, areas of interest and data, while reports only share information on these topics (Hayward, 2021).

2.5.2. Scorecard design approach

A Scorecard approach (or a Balanced Scorecard approach) is a performance measurement system developed in the early 1990s. This approach has become more popular in recent years as its purpose is to compare the strategic objectives/goals of an organisation with results.

The balanced scorecard approach enables management to link a company's performance measures with its strategy and to effectively communicate a company's mission. A well-balanced scorecard includes different performance measurements in customer, financial, learning and growth and internal business process areas.

Nine steps that can be followed to successfully create a balanced scorecard as defined by the Balanced Scorecard Institute (2022). Step one to six are used to develop/create the scorecard, while step seven to nine serves as measurement and evaluation. The steps are briefly described below:

1. *Assessment* - analyse and evaluate current external and internal environments
2. *Strategy development* - clarify and develop customer value proposition and create a high-level strategic visualising strategy.
3. *Strategic objectives development* - develop a strategy building blocks for effective planning and management of the system.
4. *Strategic mapping* - develop cause and effect links between the identified strategic objectives and the organisation's value chain.
5. *Performance measures and KPIs* - Develop performance measures and identify KPIs for each strategic objective development.
6. *Strategic initiatives* - develop strategic initiatives as it is critical to the successful development, prioritisation and implementation of a strategy.

7. *Performance analysis* - transform data in such a way that an evidence-based understanding can be obtained of the system.
8. *Alignment* - transform the formulated strategy from management-oriented to one that is focused more on individuals and something that everyone can support.
9. *Evaluation* - evaluate the work done to make the necessary changes and updates.

2.6. Alternative Solutions

When developing different alternatives to address or solve a problem, it is important to consider the inputs from a wide field of disciplines and individuals. GBV intervention attempts should be no different. Humanitarian and community-focused interventions appear to be the most popular approaches to GBV prevention according to the literature reviewed. This project however highlighted the need for engineering-based solution attempts in the GBV environment. The alternatives that can be used to address each research question are briefly discussed below, and compared against criteria to find the best approach for future stages of the research.

Research Objective 1: Develop a holistic and integrated network of GBV driving factors premised on systems thinking.

Alternative solution techniques

1. *Ishikawa Diagram* – this technique is used to identify important system variables by conducting a cause and effect analysis of the system to identify direct and indirect (or primary and secondary) causes of a defined problem.
2. *Causal Loop Diagram (CLD)* – this technique is used to illustrate how system variables are interconnected and interrelated (thus how the system variables interact with one another). It is also used to illustrate system behaviour and the effect that changes to system variables have on the system and each other.
3. *Graphical function diagrams* – this technique is used to depict the non-linear relationships that exist between system variables when they interact with one another. This non-linear relationship is plotted as a graph over a relevant range of values.
4. *Double-Q Diagram* – this technique is used to structure the activity of brainstorming to clearly distinguish between system variables that are quantitative and qualitative.

Alternative solution approaches

1. *Qualitative System Dynamics Modelling Approach* – This approach is used to gain an understanding of the feedback structures that currently exist in a system (depending on how the system is defined and the system boundaries identified). This approach allows decision-makers to gain a better understanding of the system, increase their learning of the structures within the system and enhance their future system response or intervention attempts. The approach starts by identifying the interactions and causality links that exist between system variables (assuming that all the system variables have already been identified), then identifying the direction of change between interacting variables by assigning polarities to the interactions between related system variables and finally connecting the system variables in a "cause and effect" chain to create feedback structures/processes within the system.
2. *Systems Thinking and Modelling methodology (Phase 1 and 2)* – In this approach, the problem is properly structured and the problem environment identified. Causal loop diagrams are developed with the identified system variables. This approach is taken one step further by describing the causal patterns that appear in systems' behaviour and identifying or developing system archetypes for these patterns. Once archetypes are established, leverage points must be identified where suitable interventions can be implemented and developed.

Table 6: Comparison of alternatives to address Research Objective 1

	Techniques				***Approaches***	
Criteria	Ishikawa Diagram	Causal Loop Diagram	Graphical function diagram	Double-Q diagram	Qualitative Systems Dynamics Modelling Approach	Systems Thinking and Modelling methodology
Does the technique/approach provide a holistic solution?	Yes	Yes	No	No	Yes	Yes
Is the technique/approach premised on Systems Thinking?	Yes	Yes	Yes	Yes	Yes	Yes
Is the research objective being met by this technique/approach?	Yes	Yes	No	No	Yes	Yes

Criteria	***Techniques***				***Approaches***	
	Ishikawa Diagram	Causal Loop Diagram	Graphical function diagram	Double-Q diagram	Qualitative Systems Dynamics Modelling Approach	Systems Thinking and Modelling methodology
Will the output produced from this technique/approach be effective?	Yes	Yes	No	No	Yes	No
Is the effectiveness of this technique/approach supported by literature?	Yes	Yes	Yes	Yes	Yes	Yes
Does the technique/approach produce an integrated network of system driving factors?	Yes	Yes	No	No	Yes	Yes
Result	***6/6***	***6/6***	***2/6***	***2/6***	***6/6***	***5/6***

From the binary comparison (as shown in Table 6) of the different alternative techniques and approaches that can be used to address Research Objective 1, the following techniques and approaches are best suited as they achieved the highest marks namely, the Ishikawa diagram and Causal Loop Diagram (CLD) techniques and a Qualitative Systems Dynamics Modelling Approach.

Research Objective 2: Prioritise these factors with an approach capable of assigning weights to the hierarchy of factors.

Alternative solution approaches

1. *Interpretive Structural Modelling (ISM) approach* - The model produced by this approach shows the complex structures that exist in a system/problem by utilising a designed pattern which provides insight and improved understanding into the collective relationships of a problem.
2. *Hybrid Structural Interaction Matrix (HSIM) approach* – This approach is a new means of prioritisation and uses a root-cause approach to reduce bias that is commonly found in existing prioritisation methodologies. This approach integrates features of various other concepts. This approach enables decision-makers to perform further quantitative numerical analysis of the system and its factors by integrating weights in its methodology.

Table 7: Comparison of alternatives to address Research Objective 2

Criteria	***Approaches***	
	Imperative Structural Modelling (ISM)	Hybrid Structural Interaction Matrix (HSIM)
Will this approach address Research Objective 2?	No	Yes
Does this approach prioritise factors in a hierarchy?	No	Yes
Is approach capable of assigning weights to the hierarchy of factors?	No	Yes
Will the output produced from this approach be effective?	No	Yes
Is the effectiveness of this approach supported by literature?	Yes	Yes
Result	***1/5***	***5/5***

Table 7 shows the comparison done for the various alternatives identified above. From this binary comparison of the two different alternative approaches that can be used to address Research Objective 2, the Hybrid Structural Interaction Matrix (HSIM) approach was found to be most suited as it achieved the highest mark in the comparison.

Research Objective 3: Model the complexity of the GBV problem for proper management guidance towards the provision of effective solutions.

Alternative solution techniques

1. *Spider Diagram* - This technique compares a variety of system metrics to model the complexity and the impact of a system in a simplified way, facilitating decision making and increased learning into complex systems.
2. *Stock and Flow Diagram* - This technique can be used to represent the system using a more detailed structure, by developing simulation models and performing different simulation runs with this model. Sensitivity analysis can also be performed with this diagram to identify KPIs in the system that has the greatest impact on system behaviour.
3. *Fuzzy logic* - This technique is appropriate to use for complex systems and provides a means of quantifying the interactions between the variables in non-linear systems.
4. *Time series analysis* - This technique is used to model the behaviour of a system over time by identifying any regularities/irregularities that exist within the system to ultimately quantify different system attractors.

Alternative solution approaches

1. *Quantitative Systems Dynamics Approach* - This approach is used to increase learning into the dynamic behaviour of a system by defining the system boundary and identifying the interactions and behaviour of key system variables over time. This approach utilises a stock and flow diagram that describes/depicts system structures and behaviour. Extensive simulation modelling, testing and sensitivity analysis is conducted.
2. *Systems Thinking and Modelling methodology (Phase 3,4 and 5)* - These three phases of this approach is used to perform dynamic modelling of the system, to develop scenario planning and modelling procedures for the system and to implement and facilitate organisational learning about the system/problem.

A comparison of these alternative techniques and approaches are shown in Table 8 below.

Table 8: Comparison of alternatives to address Research Objective 3

	Techniques				***Approaches***	
Criteria	Spider Diagram	Stock and Flow Diagram	Fuzzy logic	Time series analysis	Quantitative Systems Dynamics Modelling Approach	Systems Thinking and Modelling methodology
Are the research objective being addressed by this technique/approach?	Yes	Yes	No	No	Yes	No
Does the technique/approach model the complexity of the system?	Yes	Yes	Yes	Yes	Yes	Yes
Does the technique/approach provide proper management guidance to develop effective solutions/interventions?	Yes	Yes	No	No	Yes	Yes
Will the output produced from this technique/approach be effective?	Yes	Yes	No	No	Yes	No
Are the effectiveness of this technique/approach supported by literature?	Yes	Yes	Yes	Yes	Yes	Yes

Criteria	***Techniques***				***Approaches***	
	Spider Diagram	Stock and Flow Diagram	Fuzzy logic	Time series analysis	Quantitative Systems Dynamics Modelling Approach	Systems Thinking and Modelling methodology
Are there any costs associated with this approach/technique?	No	No	No	No	No	No
Does this technique/approach consider the impact of the problem on society at large?	Yes	Yes	No	No	Yes	Yes
Result	***6/7***	***6/7***	***2/7***	***2/7***	***6/7***	***4/7***

From the binary comparison of the different alternative approaches and techniques that can be utilised to address Research Objective 3, the following were found to be best suited as they achieved the highest marks after comparison namely, the Spider Diagram and Stock and Flow Diagram techniques and the Quantitative Systems Dynamics Modelling approach.

Research Objective 4: Create an interactive dashboard to serve as a measurement barometer capable of assessing and estimating the chances of GBV occurrence between two individuals of the opposite gender.

Alternative solution techniques

1. *Key Performance Indicator (KPI) Interactive Dashboard* - An interactive dashboard utilising KPIs describes as a data tool that managers and developers can use to analyse data, track and monitor trends and patterns and visually display important information. These types of dashboards allow its users and the developer to interact with and appropriately change the data and information to make more informed decisions.
2. *Scorecard approach* - This approach serves as a performance measurement system to link a system or process performance measurements with its goal and strategy.
3. *Basic reporting* - This technique provides factual information based on progress and performance measures and monitors the effectiveness of a process or system to determine if the goals/objectives of that process or system are achieved.

Table 9: Comparison of alternatives to address Research Objective 4

Criteria	***Techniques***		
	KPI Interactive Dashboard	Scorecard approach	Basic reporting
Will this technique address Research Objective 4?	Yes	Yes	No
Will this technique be able to measure the correct system metrics?	Yes	Yes	No
Is the technique suitable to assess and estimate the likelihood of GBV occurrence/risk between two individuals?	Yes	No	No
Will the output produced from this approach be effective?	Yes	Yes	No
Is the effectiveness of this approach supported by literature?	Yes	Yes	Yes
Does this technique have cost associated with it?	No	No	No
Result	***5/6***	***4/6***	***1/6***

The bi-comparison of the different alternative techniques able to address Research Objective 4 (as shown in Table 9), illustrates that an interactive dashboard is the most appropriate technique to use. This is discussed in more detail during the preferred solution section.

From this evaluation, it is evident that an engineering-based approach to GBV intervention attempts will be effective in addressing the defined research questions and objectives of this project. The techniques and approaches identified in this section form the preferred solution for the project and are presented in the next section.

2.7. Preferred Solutions

There is no current literature that supports the use of an engineering-based solution for GBV prevention and modelling attempts. This is why an engineering-based solution is chosen as the preferred solution for this project utilising various engineering-based techniques and approaches which aim to supplement the existing pool of literature in this field. This solution aims to meet the four research objectives developed in Chapter 1 of this project.

The proposed artefact that this solution will attempt to successfully develop is an interactive dashboard barometer capable of measuring, assessing, and estimating the chance of GBV occurrence (in any form) between any two opposite gendered interactors. Research objective 4 will be met if this barometer is successfully developed and produces accurate reliable results.

Data inputs to this barometer will be in the form of Key Performance Indicators (KPIs), a weighted hierarchy of factors (using the HSIM technique) and a quantified GBV complexity diagram (using a Spider Diagram). To create the weighted hierarchy, all relevant and reasonable GBV causes have to first be identified. This identification is done by reviewing literature from various studies and organisations. The identification of these causal factors and representing these factors and the interactions that exist among them (utilising an Ishikawa diagram and a CLD) will address research objective 1.

Once identified the HSIM approach can be utilised to prioritise the identified GBV causal factors in a weighted hierarchy. Research objective 2 will be met once weights have been assigned to the various factors, and these factors are ordered in a hierarchy. The quantified values obtained from this HSIM technique can be used as input for the GBV complexity diagram. A complexity modelling technique namely a Stock and Flow Diagram may be used to graphically display the complexity of the system. With this diagram, various simulation runs can be performed for different system scenarios. A sensitivity analysis can be performed in conjunction with this diagram to identify the KPIs that have the biggest impact on the system. With this, research objective 3 will be met.

The methodology to be followed for this proposed solution is depicted in the conceptual framework in Chapter 3.

Chapter 3
Research Methodology

3.1. Brief review of different Research Methodologies

Various research methods can be effectively used for social system problems. A brief review of different research methods applicable to this project is provided in the paragraphs that follow. Research methods discussed include (1) Case Study Research, (2) Grounded Theory research, and (3) Mixed Methods Research.

Case Study Research

Case study research is ideal to use for an in-depth and holistic analysis and an investigation into a topic is required. This type of research provides a detailed viewpoint from various participants and data sources used in the study. When case study research is conducted, the researcher will follow a method that is well established and tested in a wide array of research fields. Tellis (1997) describes four stages to follow when conducting case study research. These stages include:

1. Case study design.
2. Conduct the case study.
3. Analyse the case study and its evidence.
4. Develop recommendations, draw conclusions and provide implications for the case study.

Case study research provides a multi-perspectival analysis and can be applied in the following situations namely, (1) when complex links within real-life systems and interventions need to be explained, (2) when the real-life context of a problem or system in which an intervention has occurred need to be described, (3) to describe an intervention, (4) when the intervention being evaluated in the problem or system has no clear outcome(s).

Case studies are described as one of the best techniques to use when developing new research. This methodology provides detailed qualitative information and insight into a system for further research. When a case study is completed and provides valuable findings and results, it leads to advanced new research in that research field.

Different types of cases exist in case study research. A single case is utilised to challenge a unique theory or case (Tellis, 1997). Single-case studies can be holistic or can occur when multiple units of analysis are required for the same case. Multiple-case studies follow the logic of replication. Each of these case studies consists of a complete and separate study. Here data is gathered and facts are obtained from different primary or secondary data sources and where conclusions are drawn from this.

Grounded Theory

The Grounded theory research methodology is a qualitative method that allows individuals to study a certain phenomenon, process, or system and to discover new and emerging theories based on the collection, interpretation, and analysis of real-world data (Delve, 2021). This approach is described as the most prominent methodological perspective in conducting qualitative research within the social sciences environment (Haig, 2010). Grounded theory differs from other traditional approaches, as it uses an inductive approach to create new theories from data.

The Grounded theory should be considered in situations where no theory exists that provides an explanation for a certain phenomenon, or if a theory exists, but this theory is potentially incomplete. Grounded theory is appropriate and effective when studying individuals' understanding of the world, its complex nature, and how this is related to their social setting. The steps for carrying out research with the grounded theory method are illustrated in Figure 4.

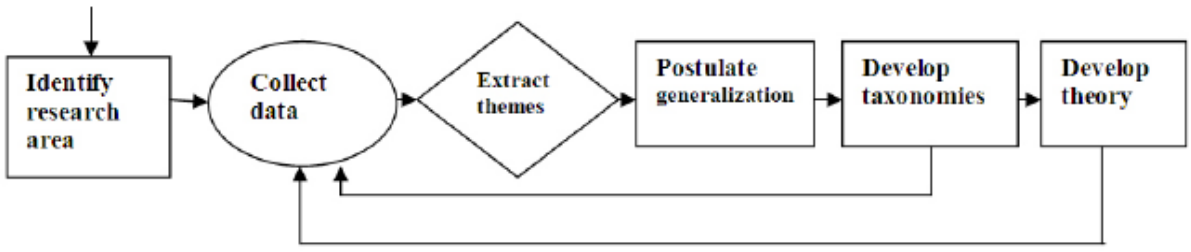

Figure 4: Grounded Theory methodology steps

Grounded theory has various benefits as a research methodology, namely that findings from this approach represent accurate real-world environments and settings and provide the opportunity for discoveries. This approach also allows for the collection and analysis of data to be streamlined and prevents bias in judgement. Grounded theory's limitations are however that a lot of time is required to collect data and it provides various challenges during analysis.

Mixed-methods research methodology

A mixed-methods research methodology combines both qualitative and quantitative data in one single investigation. This methodology allows for a more complete, in-depth, and integrated utilisation of data than the separate use of qualitative and quantitative data collection and analysis techniques would. This research approach originates from social sciences but has been used in many other fields in recent times.

Wisdom and Creswell (2013) provide different steps to follow when conducting research with a mixed-methods study namely,

1. Determine if the use of a mixed-methods research design is appropriate and will be effective for the specific study
2. Formulate the rationale behind using a mixed-methods study
3. Select the various mixed methods to use in the research design
4. Collect relevant data with qualitative or quantitative techniques
5. Analyse the data with appropriate qualitative or quantitative techniques
6. Validate the data used during the study
7. Interpret the data and results
8. Write a research report and state findings from the study

Wisdom and Creswell (2013) also state that some of the key characteristics of a mixed methods study that is well defined include that data collection and analysis takes place qualitatively and quantitatively and that qualitative and quantitative data is integrated during the investigation. In a book released by Mackey and Bryfonski (2018), it is said that mixed-methods research has been applied to many social science studies over the past years. This research methodology is advantageous as it provides the opportunity to gain a complete picture and a better understanding of a certain phenomenon being researched. This is done by triangulating data from various qualitative sources and different quantitative data.

3.1.1. Research methodology selection

It is important to select an appropriate research methodology when doing research projects. The choice of selecting the best research methodology is a difficult one, as more than one methodology may apply to the problem under investigation. Goulding (2002) states that this selection should be made, based on the researchers' beliefs, interests, and convictions. The research aim, and previous research done in similar fields can also guide and ease the selection

process. Table 10 below show criteria considered to select the best research methodology, based on the researchers' intuition.

Table 10: Comparison of research methodologies

Criteria	***Case Study Research Methodology***	***Grounded Theory Research Methodology***	***Mixed Methods Research Methodology***
The research methodology uses qualitative data and techniques	Yes	Yes	Yes
The research methodology uses quantitative data or techniques	Yes	No	Yes
The research methodology can be applied to social systems	Yes	Yes	Yes

From Table 10, one can see that case study research and a mixed methods research approach would be best suited for this problem. Case study research is more appropriate to use for this research as very specific system boundaries need to be defined for this system. Due to the ever-changing nature of GBV, modelling this system will be difficult if boundaries are not established. Therefore, the case that will be considered during the research is a GBV system taking into consideration primary and secondary system drivers and the impact that these have on individuals. With this, an improved insight of the problem environment may be obtained and a better solution attempt may be developed. The conceptual and theoretical framework presented in the rest of the chapter encompasses and illustrates the selected research approach to be followed for this project.

3.2. Conceptual Framework

The conceptual framework in this section demonstrates how the main project areas will be organised and used to achieve the project's objectives. The conceptual framework for this project can be seen in Figure 5 following.

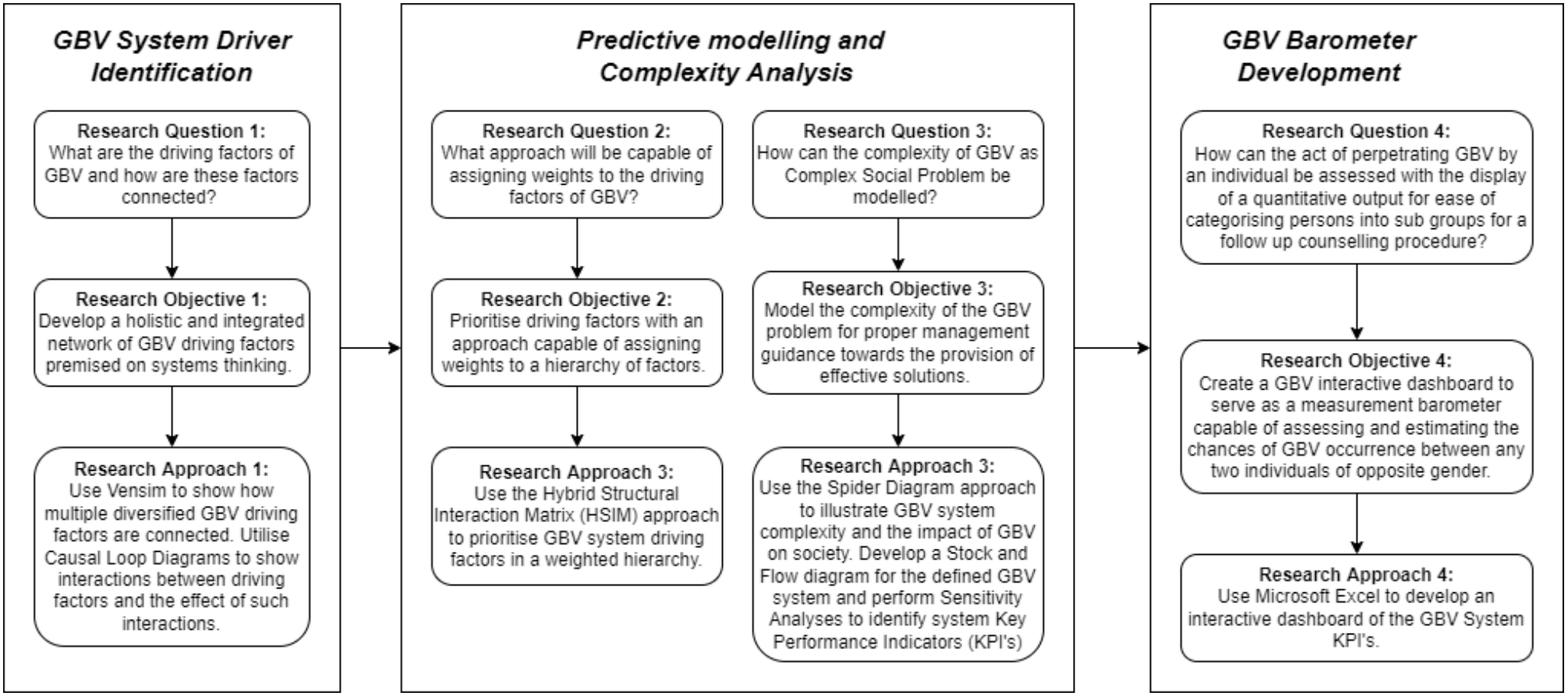

Figure 5: Conceptual Framework

3.3. Theoretical Framework

The theoretical framework presented in this section guides the theories behind the different tools and methods that were identified and selected for this project.

3.3.1. Causal Loop Diagrams (CLD)

Causal Loop Diagrams (CLD) or alternatively called Multiple Cause Diagrams (MCD) is a simple but effective way of finding and visually illustrating causal relationships between system entities. This tool captures system behaviour and defines how system variables interact and interrelate. CLDs are generally used to enhance one's understanding of a complex problem. These diagrams indicate how small system changes can have a significant effect on the overall system behaviour, utilising feedback loops.

The following steps are required to construct a CLD:

Step 1: Identify the direction of causality between two or more system variables by using arrows.
Step 2: Identify the type of change effect that exists between the system variables, by using positive and negative polarities.

- "**+**" polarities indicate that an increase in one system variable causes another system variable to increase as well (and vice versa).
- "**-**" polarities indicate that an increase in one system variable causes another system variable to decrease (and vice versa).

Step 3: Connect system variables to indicate the effect of change that exists between them. Two types of feedback loops exist when modelling interactions between system entities namely, Balancing Loops (B) and Reinforcing Loops (R).

- "**B**" is assigned when a feedback loop contains more positive than negative polarities.
- "**R**" is assigned when a feedback loop contains an odd number of negative polarities.

Figure 6 diagrammatically depicts the generalised symbols used when constructing a CLD.

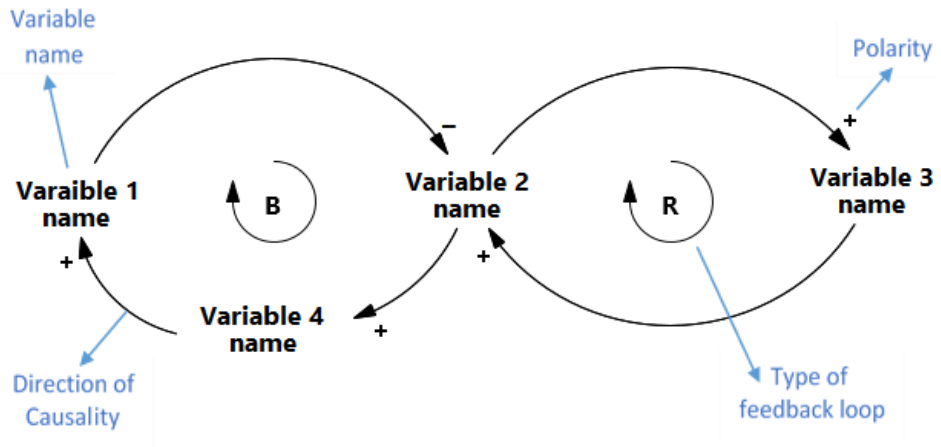

Figure 6: Generalised CLD symbols

3.3.2. Hybrid Structural Interaction Matrix (HSIM)

Figure 7 shows the 10 steps to be followed to carry out the HSIM process application. These steps are briefly discussed in the paragraphs that follow.

Step 1: List all relevant factors (here it will only be system factors and not Quality Management Factors (QMFs) as depicted in the figure) and number these factors serially (i.e. When ten factors are listed in the problem space, they will be numbered from one to 10 respectively).

Step 2: Set up a contextual relationship for the factors identified in the previous step. Only the interactions that are coherent to this relationship should be considered. This relates to the presence of asymmetry that if e_{ij} equals 1, then e_{ji} would equal 0.

The relationship that must be used for the development of the HSIM approach questions: "does the implementation of a factor *j* lead to the possible actualisation of factor *i*? ". This relationship is represented as follows:

$$e_{ij} = \begin{cases} 1 \; if \; i \; is \; achieved \; because \; of \; j \\ 0 \; if \; i \; is \; not \; achieved \; because \; of \; j \end{cases}$$

Where e_{ij} represents a unique element in row "*i*" and column "*j*". A *0* is assigned if a *"no"* response is provided for the contextual relationship, and a *1* is assigned if the response to the contextual relationship is *"yes"*.

Step 3: Create a square matrix with a dimension of *n+1*. Here *n* refers to the number of factors that must be considered, as identified in step 1. The diagonal entries of this matrix are 0. An example template of this matrix is shown in Figure 8.

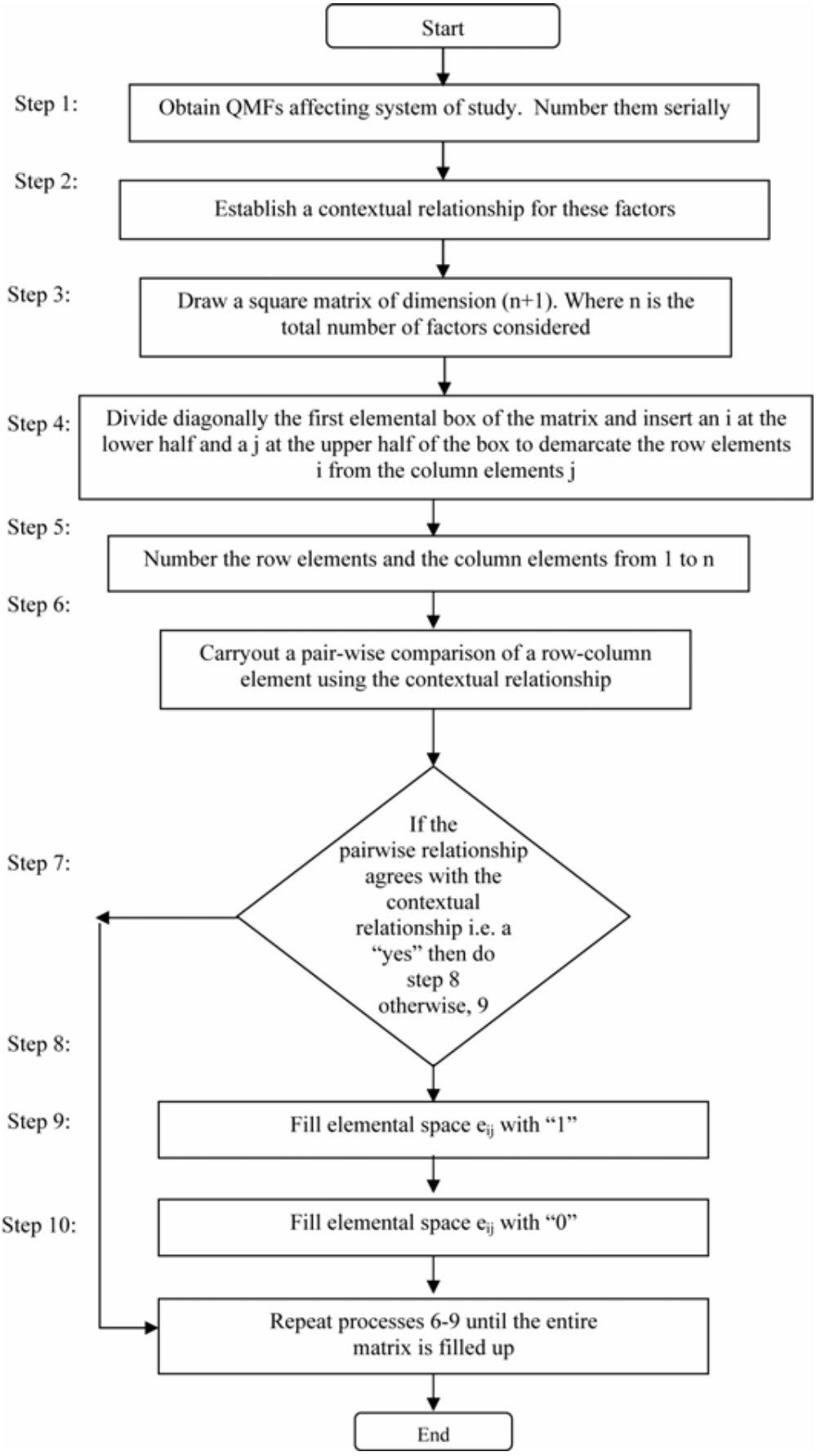

Figure 7: Hybrid Structural Interaction Matrix (HSIM) process steps (Ayomoh and Oke, 2006)

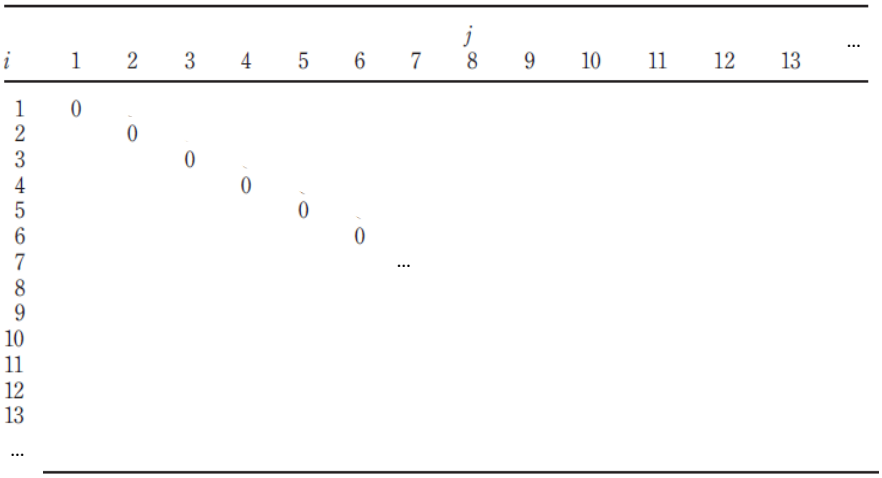

Figure 8: Square matrix of dimension (n+1) adapted from (Ayomoh and Oke, 2006)

Step 4: Demarcate raw elements from the column on the matrix's diagonal symmetry line. The upper right portion (representing the column elements) and lower left portion (representing the row elements) of the matrix are assigned to both variables *j* and *i* respectively.

Step 5: Number all considered factors serially from *j* to *n*. This numbering is symmetrical for both variables *i* and *j* (i.e. $i \equiv j, i+1 = j+1, i+n = j+n$).

Step 6: Ensure that all variables have been clearly defined and numbered serially in the square matrix.

Step 7 through 10: Use the contextual relationship defined in Step 2 to fill up the matrix. Repeat these steps until the matrix is complete.

3.3.3. Stock and Flow Diagrams

A Stock and Flow diagram is created by using the CLD developed for a specific system or process. The steps that should be followed when converting a CLD into a Stock and Flow diagram are presented below.

Step 1: Specifying the units of all the variables on the CLD - In doing this it enables the system analyst to determine if there is a time associated with a variable, if it is a constant or if it shows a rate of change.

Step 2: Identifying and creating stock variables - Identify the stock variables of the defined system. Stock variables are the system variables that you want to measure at a specific point in time.

Step 3: Identifying and creating flow variables - Identify the flow variables of the defined system. Flow variables are variables that either add to stock variables or subtract from them.

Step 4: Connecting stock and flow variables - Firstly connect all the identified flow variables to the stock variables that they influence. Secondly, connect all the stock variables to the flow variables that they influence (if any).

Step 5: Linking (and adding) any remaining system variables - Identify, add and link all auxiliary variables from the CLD that were not defined as stock and flow variables. Auxiliary variables refer to variables that either have constant values or that are based on calculations.

Step 6: Defining stock and flow variables - Defining and specifying the equations of the defined stock and flow variables and making sure that no errors in the model equations exist. When running the simulation model with these equations, it produces values for these variables at specific time points.

Step 7: Linking (and adding) any additional system variables - Defining and identifying any new/additional variables that allow for the conversion process to be completed. This also ensures that the simulation model is calculable.

Figure 9 below depicts the basic elements used in a Stock and Flow diagram.

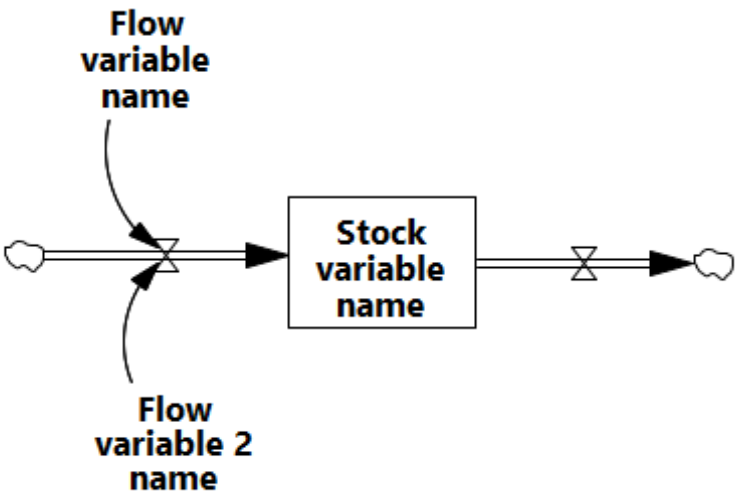

Figure 9: Generalised Stock and Flow Diagram symbols

3.3.4. Interactive Dashboard Application

There are various areas and aspects that need to be considered when looking to design a dashboard. Some of these aspects include the available data, the data that needs to be portrayed, the need to visualise data and how which the data needs to be visualised. To ensure that a dashboard is effectively designed and developed, the following steps can be used as guidance.

Step 1: Assess the need/goal **-** It is important to establish a clear goal and understanding of the dashboard and its associated objectives. The audience of the dashboard (i.e. Those individuals who will use it or who may be impacted/guided by it) needs to be determined. The output that the dashboard needs to produce has to be determined along with actions/response measures that will be taken to address/improve the dashboard output.

Step 2: Make a dashboard prototype **-** A dashboard prototype can be developed after a clear understanding is obtained regarding the dashboard objective(s) and information items available. This prototype enables the developer to gain a better understanding of the dashboard elements (as this prototype aims to determine and define the various sections of information/data that will be present on the dashboard). The prototype does not have to be a working model and can be a simple schematic/drawing. The purpose is to illustrate how data should be arranged in the dashboard and why this data is important.

Step 3: Select the appropriate charts **-** Using the most appropriate chart to display/visualise important patterns and trends in the data is key. In using the correct chart type and style, the dashboard provides the developer and the dashboard users(s) with additional insight into the problem/system that would not have been achieved by looking at the data separately. Use line charts, bar charts or area charts when illustrating trends over time. Use bar charts when comparing or ranking items. Use box plots or a histogram to illustrate data distributions. Use scatter plots to depict the correlation between system entities etc.

Step 4: Check the effectiveness of the charts **-** It is important not to overload the charts on the dashboard with info that may be irrelevant. If a lot of data needs to be displayed, create divisions in the chart or dashboard to make it easier to understand. Select the right place for the charts on the dashboard and ensure that the orientation of the chart is correct (questions must be easily answered from the charts). Finally refrain from using too many different colours in the dashboard or the charts themselves (stick to three or four complementary colours).

Step 5: Obtain feedback and make the necessary changes - Gather suggestions and feedback from the dashboard users/audience. This feedback allows the developer to evaluate the dashboard and the work that they have done better. Ensure that the dashboard meets its goal and answers the questions that it is designed to do. Ensure that the chart type and style that is used are the most appropriate and can be easily understood. Improve the dashboard design and make the necessary changes based on the feedback obtained.

Figure 10 below illustrates the dashboard prototype developed for the defined GBV system. In this diagram, the general look of a dashboard and its symbols are shown.

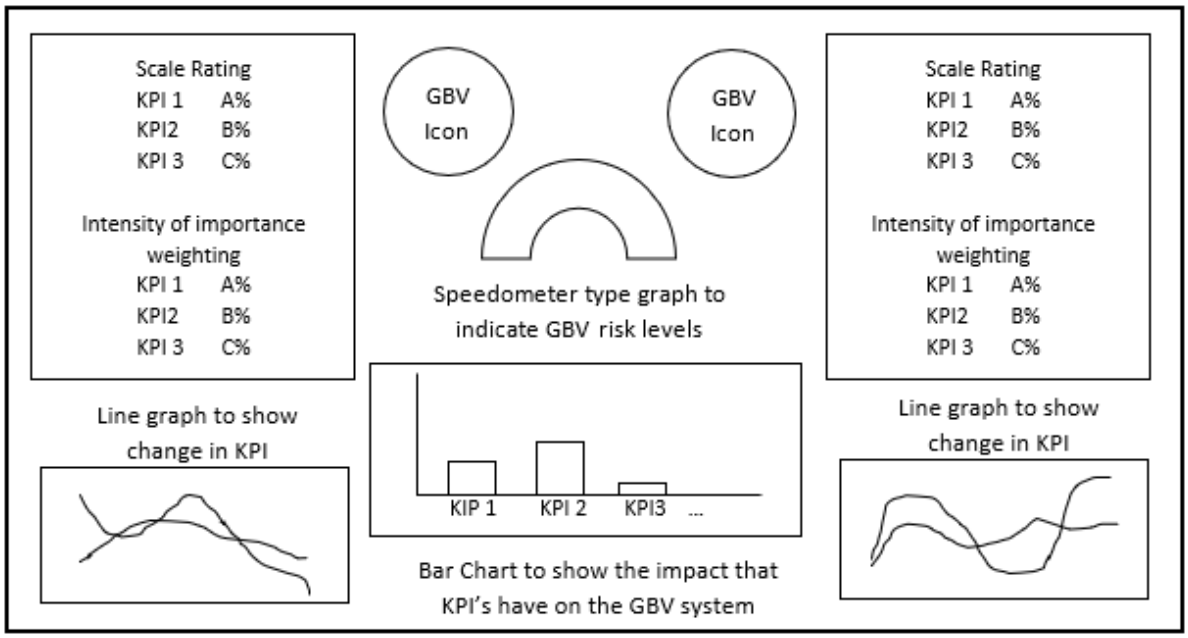

Figure 10: KPI Interactive Dashboard prototype for the defined GBV system in study

This chapter serves as input to the next chapter. In this chapter a Case study research methodology has been selected as most suitable for this research. The conceptual framework for this research has been defined. A theoretical framework was developed for the techniques and methods contained in the conceptual framework. The theoretical framework provides detailed steps to follow for easy execution of the said techniques and methods.

Chapter 4
Data Presentation and Results

4.1. Overview

The data presented in this chapter is a combination of qualitative and quantitative data. The qualitative data presented in this chapter was collected from various literature sources on GBV, its causes, and its related statistics. This qualitative data formed the basis from which quantitative data was developed and the analysis initiated and executed. Weighted numerical values were calculated and assigned to qualitative factors during analysis to determine a hierarchy of factors for prioritisation. This is also used during the application and deployment of the barometer dashboard in a later phase of the research.

Results obtained from the analysis were discussed in detail in this Chapter. The results indicate that applying engineering-based principles and techniques to the GBV system is effective and that when key system areas are addressed and appropriate solutions proffered a positive effect on the system was noted.

4.2. Data Analysis and Results

The analysis starts by identifying the various drivers of the GBV system under investigation. This identification was done by reviewing different sources as discussed in the literature review. The drivers of a GBV system can be grouped into two categories namely primary and secondary system drivers. The secondary system drivers were selected based on the principle of functional homogeneity (i.e. drivers that have a resemblance in their functional capabilities were grouped into clusters). The primary drivers were given broad titles that can host the various clusters formed by the identification of the secondary system drivers. The primary drivers are facilitated by the secondary drivers. Note that this classification has no effect on the later phases of analysis and serve as a way to understand the system in a simplified way.

The identified secondary system drivers are external factors to which an individual is or can be exposed during their lifetime. This affects the primary system drivers and influences how a

person behaves, what behaviour a person finds acceptable in a relationship and how prone a person is to become either a victim or perpetrator of GBV. The drivers identified as primary to the system are broad terms used to describe the factors that have a direct impact or affect on GBV. Drivers identified as secondary drivers describe the factors that do not directly impact or affect GBV. These drivers have an impact on the primary system drivers within this system, ultimately impacting GBV itself.

Figure 11 illustrates the defined GBV system. At its core is a complex and dynamic social system of GBV. When expanded, the primary and secondary system drivers enclose this GBV system has a direct and/or indirect impact on the system itself. The direction of the impact between primary and secondary system drivers and GBV is twofold namely, secondary system drivers affect primary system drivers which ultimately affect the GBV system and GBV as the system itself affects both primary and secondary system drivers respectively.

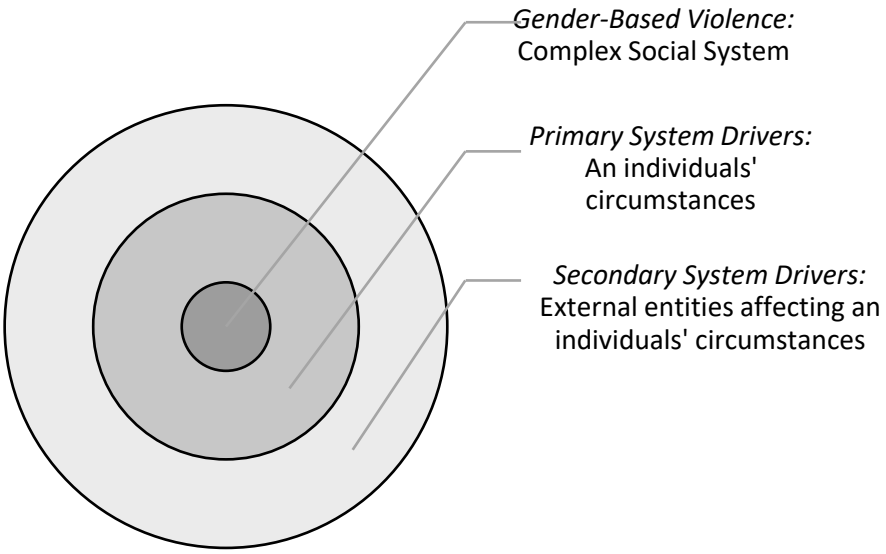

Figure 11: Representation of the GBV System

The primary and secondary system drivers were identified and obtained from various literature sources. Many of the sources reviewed showed similar system drivers but used different naming conventions for these drivers. The drivers listed in Table 2 contain most of these system drivers, with many of the drivers corresponding with other sources. Information such as these system drivers obtained from any of the organs of the United Nations including the WHO are reliable as it is based on global research with to access to a greater availability of funds and expertise and a wider survey space. Some of the system drivers used in this research was however developed using original critical thinking and not relying solely on the literature.

Literature refers to these system drivers as causes or risk factors (i.e. factors that pose a risk to GBV and its prevalence rates). It is argued that these factors should however be referred to as "drivers", as it is rarely possible to attribute the cause(s) of violence to a single factor. The primary system drivers are listed and described below.

- ***Biological factors:*** refers to factors that can affect a person's function and behaviour. These factors are the primary determinants of a person's behaviour.
- ***Personal factors:*** refers to the characteristics of a person that influence their decisions and learned behaviour.
- ***Societal factors:*** refers to factors that affect a person's lifestyle and behaviour within society.
- ***Economic factors:*** refers to factors that can influence and affect a person's financial status and associated behaviour.
- ***Substance abuse:*** refers to factors that lead to the excessive use of substances (such as alcohol and drugs) which could lead to behaviour that causes physical or social harm.
- ***Religion and cultural practices:*** Refer to factors that influence a person's morals, beliefs and cultural or worldviews which ultimately impact their behaviour.

The identified secondary system drivers associated with each primary factor are described in the paragraphs that follow and are visually depicted in the fishbone diagram in Figure 12 following.

The secondary system drivers identified for *Biological factors* include:

- Age
- Race
- Sex, and
- Mental health problems

The biological factors of an individual can make them more susceptible to GBV exposure. Victims of GBV are mostly adolescents or young individuals. Individuals of all age categories, ranging from infancy to old age, can however experience GBV. Globally, certain racial and ethnic groups are more vulnerable to violence. This vulnerability is evident in poor and or rural communities where individuals (victims of violence) are dependent on the resources and livelihood of others. An individual's sex (the physiological and biological characteristics of a male and female) affect the likelihood that they will become a victim or perpetrator of GBV. Mental health problems in an individual can affect how they behave during violent events.

Various societal and religious factors have been found to influence or cause mental health illness in an individual. Other factors including poverty, social disadvantage, neglect, childhood abuse and discrimination have all been found to affect a person's mental health.

The secondary system drivers identified for *Personal factors* include:

Grouping 1:

- Level of education
- Income
- Opportunity for economic advancement
- Gender
- Identifying as part of the LGBTI community
- Health

Grouping 2:

- Exposure to maltreatment as a child
- Witnessing parents being violent as a child
- Being exposed to violence between primary caregivers
- Exposure to controlling behaviour between parents
- Lack of emotional bonding with parents as a child
- Growing up with parents who use poor parenting practices
- Family dysfunction or separation
- Family honour
- Marital status

The drivers that influence the personal factors of an individual can be divided into two groups of related factors as shown above. An individual's gender or associated gender (i.e. Individuals associating as being part of the LGBTI community) could lead to GBV. Violent attacks directed specifically toward members of the LGBTI community have grown in recent years and various gender communities have become targets for GBV and other violent attacks. An individual's health is also greatly affected by GBV. It has been noted that GBV can lead to health problems or related complications such as sexual health problems (including HIV/AIDS and sexually transmitted diseases), depression, anxiety, post-traumatic stress disorder (PTSD) chronic health problems including chronic pain and high-risk pregnancies. Health-related problems seen in a mother can also be transferred to children during infancy and later stages of life.

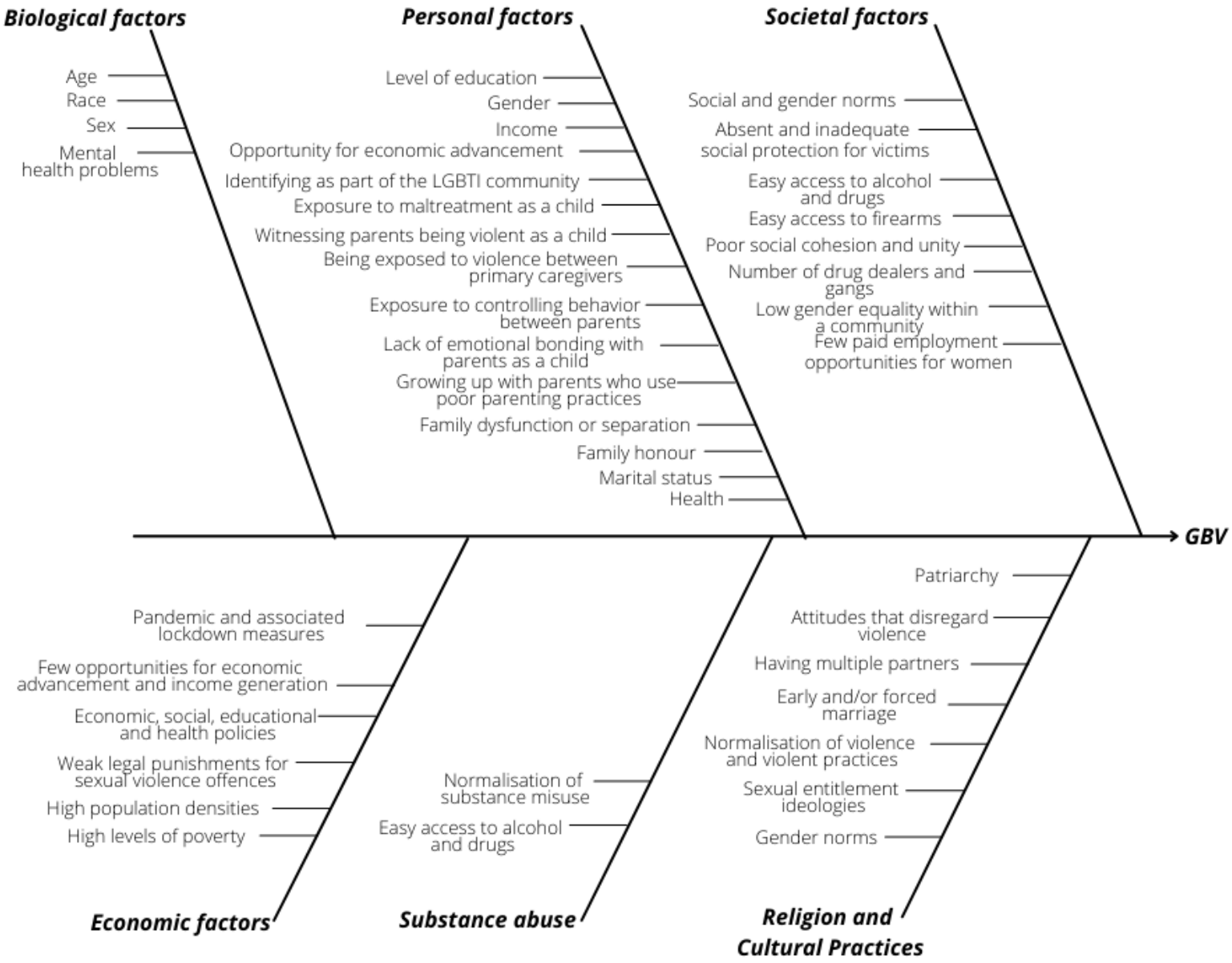

Figure 12: GBV System Root Cause Diagram

Low levels of education and opportunities for income generation or economic advancement can influence how a person behaves in violent situations. Many women worldwide experience minimal economic independence and studies have found that empowering these women can lead directly to Intimate partner violence (IPV) within their relationships (Rahman et al., 2011). Therefore, the empowerment of women within a society can increase their risk of being exposed to violence and abusive behaviour in a relationship.

It can be difficult for women who find themselves in an abusive relationship to report this abusive behaviour if they depend on their partner's economically and financially. Many women have however become strong and independent individuals in society and do not depend on the livelihood of others. Some studies have found the relationship between the empowerment of women and domestic violence (DV) to be inversely proportional (Rahman et al., 2011).

The second grouping all relate to an individuals' experience and relationships they had at a young age. Children often subconsciously mimic the behaviour of their parents when they are older. If violence and violent behaviour are normalised as a child or at a young age, similar behaviour during adulthood will not raise any concern within these individuals. If a child is continuously exposed to controlling behaviour from their parents or caregivers, they grow up rarely having control over a situation. Once these children grow up there is a chance that they can use a similar form of controlling behaviour (as seen in their parents and or caregivers) to remain in a position of power and control in certain situations. GBV and other violent behaviour can thus become a gateway for these individuals to retain control over a situation or person.

The marital status between two individuals plays a big role in GBV and related forms of violence. It has become more common that two individuals live together even though they are not married. Women do not have marital rights or privilege in these situations which can lead to increased levels of violence experienced by their partners, making it difficult for these women to leave such a situation.

The secondary system drivers identified for *Societal factors* include:

- Social and gender norms
- Absent and inadequate social protection for victims
- Easy access to alcohol and drugs
- Easy access to firearms
- Poor social cohesion and unity

- Number of drug dealers and gangs
- Low gender equality within a community
- Few paid employment opportunities for women

One of the main issues faced by society and specific victims of GBV is inequitable gender norms (Ramsey, 2016). Violence is normalised in different cultures due to a strong sense of gender privilege, entitlement and rigid social norms. Social and gender norms are often used to justify violent behaviour, specifically GBV. Various socio-cultural theories that relate to violent behaviour indicate that the violence directed toward a specific gender is due to a society's shared and pre-set attitudes. Studies have found that when the attitudes within a society is characterised by high gender equality rates and low violence tolerance and the occurrence of violence directed toward women in that society is decreased (Nayak et al., 2003). Studies show that gender and social norms grant men with more power and control over women and can lead to or encourage risky and violent behaviour.

Substance abuse (i.e. Alcohol and drug abuse) have been linked to GBV in the past, as the risk of violent behaviour in a person using substances is increased. Evidence suggest that women living with men who misuse substances are five times more likely to be violently assaulted by that partner than a woman whose partner does not use substances. Studies have also found that substance use is one of the primary contributors to violent behaviour in a relationship and that it is the main differentiating element between violent and non-violent men.

The secondary system drivers identified for *Economic factors* include:

- High levels of poverty
- Few opportunities for economic advancement and income generation
- High population densities
- Weak legal punishments for sexual violence offences
- Economic, social, educational and health policies

Poverty can increase violence and GBV in many different ways. The likelihood that women and young girls will experience poverty and sexual exploitation is high as poverty cause fewer employment and education opportunities. The various economic, social and health related policies of a certain region has an impact on the degree of violence and legal punishment for violent offences. If legal actions and punishment measures are lacking, perpetrators easily get away with violent crimes and or sexual offences. The criminal justice system in SA has failed

GBV victims a countless number of times, and perpetrators rarely get convicted for their crimes. Studies show that very few of the perpetrators of reported rape cases get convicted. There is also often a lack of caring behaviour towards victims from police officials.

Pandemic scenarios and their related lockdown measures (as in the case of the recent Covid-19 pandemic) may lead to increased levels of GBV. During the Covid-19 pandemic, individuals were forced to live together in isolation. The isolation period and lack of income generation caused tension in many relationships and households. This lockdown situation made it difficult for women to escape from the violence directed toward them. The lockdown measures also made it difficult for these women to reach out for help. Women were trapped in an endless cycle of violence. The number of reported GBV cases during this time increases so much that some people even stated that it can be seen as a pandemic itself (Dlamini, 2021).

The secondary system drivers identified for *Substance abuse* include:

- Easy access to alcohol and drugs
- Normalisation of substance misuse

Substance abuse has been linked to GBV, as it increases the likelihood of violent behaviour in an individual. Studies indicate that the use of substances is one of the primary contributors to violence in a relationship. The term substance is used to describe both alcohol and drugs. Evidence exists showing that when two individuals live together and one of them excessively use substances the other is five times more likely to be violently assaulted by that partner, in comparison to instances where neither party uses substances. Many cultural and gender norms encourage violent and risky behaviour encouraging men to link their authority and masculinity to substantial substance use. Therefore, the excessive use or consumption of substances by men increases a women's risk of violence and abuse.

The secondary system drivers identified for *Religion and Cultural practices* include:

- Gender norms
- Sexual entitlement ideologies
- Normalisation of violence and violent practices
- Early and/or forced marriage
- Having multiple partners
- Attitudes that disregard violence
- Patriarchy

Various studies indicate that there is a link between cultural practices and GBV. These cultural and religious practices have been normalised for many years, and both men and women adhere to them. These practices have been found to promote GBV and can either cause explicit or implicit harm to a person. Studies indicate that religion and cultural practices can be a direct cause of GBV, as it allows a perpetrator to misuse their power over others and ultimately hurt their victims. In many cultural practices, men are seen as the more dominant gender and women have to be submissive toward them. Patriarchy is found to be one of the main causes of violence directed toward women, specifically in a relationship (Dutton, 1994). Arguably all men can use violence against a woman as means of reinforcing their power.

4.2.1. Cluster Driving Factors into "Cause" and "Effect" Relationships

While reviewing literature in the field of GBV and its associated system drivers, the relationships between these entities were identified. This identification was done for the direction of interaction and type of feedback between different system drivers. The Causal Loop Diagram (CLD) in Figure 13 depicts the cause and effect relationship of the primary system drivers on GBV and one another. The relationship that exist between GBV and the system drivers in the opposite direction were omitted in this diagram for purpose of simplicity. This CLD was constructed with Vensim PLE software based on an indirect approach in which various system elements and the different relationships among them were identified. Positive feedback (indicated in this figure by a "+" sign) shows that a change in the primary system driver leads to a similar direction change in GBV levels and or another driver. For example, if the degree of substance abuse in a relationship between two individuals is high/increases, the likelihood that GBV will be present in that relationship also increases and vice versa.

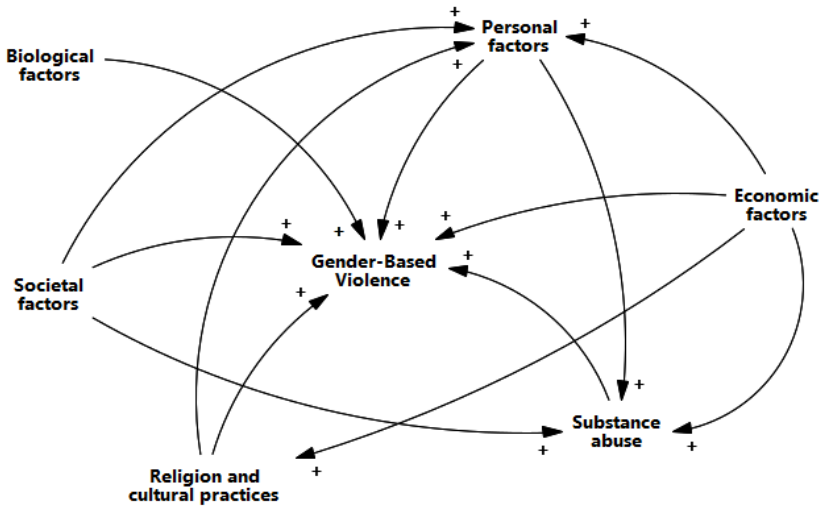

Figure 13: CLD showing primary system drivers

When expanding this CLD view of the GBV system, it is important to look at the effect that the identified secondary system drivers have on GBV and on one another as this allows for an improved understanding of the cause and effect relationship of this system and its complexities.

It is also important to note that within this system it is not only the identified system drivers that has an impact on GBV, but GBV in turn too have an impact on the system drivers themselves. The impact that GBV has on its victim(s) varies greatly depending on the nature and particulars of the offence and the relationship between the victim and perpetrator. GBV also has an impact on a victim's family members, dependents, the perpetrator himself/herself and the other individuals within the victim's close community or society. The implications that GBV has on individuals in each of these areas are summarised in Table 11. This information was obtained from literature. This impact is described in more detail in the paragraphs that follow.

Table 11:Effect of GBV-related factors on various individuals

	Victim	***Family member(s)/ dependants***	***Perpetrator***
Injury	x		
Disability	x		
Sexual health problems	x		
Sexually transmitted diseases (STD's)	x		x
HIV/AIDS	x		x
Reproductive health problems	x		
High-risk pregnancies	x		
Chronic health problems	x		
Hypertension	x		
Chronic pain	x		
Fear/Anxiety	x		x
Distrust	x		
Depression	x		
Post-traumatic stress disorder (PTSD)	x		
Suicidal thoughts	x		
Alcohol or drug abuse			x
Isolation	x	x	
Withdrawal	x	x	
Mental illness	x		x
Broken homes/family separation		x	
Divorce		x	
Nightmares	x		

	Victim	*Family member(s)/ dependants*	*Perpetrator*
Aggression		x	x
Low self-esteem	x		
Premature birth	x		
Shame/rejection from community or family	x	x	x
School dropout	x	x	

A victim of GBV's health is greatly impacted by GBV as it can cause serious short and long terms health problems. Health-related problems can be grouped into both physical and psychological problems. Physical health problems seen in victims include injury or in extreme cases of disability, sexual health problems (including sexually transmitted diseases and HIV/AIDS), reproductive health problems such as high-risk pregnancies and other chronic health problems such as hypertension and chronic pain. At a psychological level, the effect on a victim can be observed at a direct and indirect level. At a direct level, a victim can be left with anxiety after an attack, leaving them in a situation where they struggle to trust others. GBV also leave its victims feeling depressed and lonely and can lead to post-traumatic stress disorder or suicidal thoughts. At an indirect level, the impact of GBV may lead to alcohol or drug abuse, isolation and withdrawal or other mental illnesses.

A victim's family members and close dependants are affected by GBV and the collateral effects that it has on the victim. GBV has been found to lead to broken homes, family separation and divorce. It can in some instances also cause behavioural and emotional disturbances including nightmares, aggression against other individuals and low self-esteem. Children of a GBV victim are also affected by premature birth (when the mother is abused during pregnancy) which increases their risk of growing up to be a perpetrator of violence or a victim of GBV violence themselves. GBV can also humiliate a family if one of their family members has been a victim of this kind of violence and can lead to rejection from the community or society in which they live. Perpetrators of GBV themselves too are affected by their actions. Perpetrators can be sanctioned by their communities and many experience fear and anxiety over possible legal action(s), arrest or imprisonment. The perpetrator in many cultures and societies get shamed by their families and close relatives.

The final two areas in which individuals get affected by GBV are within a community/society and in an economic context. In a community, an individual (be it a victim of GBV or just a

regular community member) can be reluctant to participate in various social and economic activities due to the fear of violence. This fear of being attacked or assaulted may hinder individuals to venture into the outdoors and participate in outdoor activities such as running or walking. Women within a community are more vulnerable and susceptible to violence being directed toward them which could result in absenteeism at work and reduced income-generating opportunities.

At an economic level GBV places a burden not only on the health system but also on the justice system itself. Economic stability and productivity growth are hindered as women's participation in and contribution to certain areas within the economy is reduced in the presence of GBV. The problem that an economy and the individuals within it face is that rapid economic and social change is constrained and the effective implementation of appropriate legal action, laws and prevention strategies is difficult and often fails its victims.

From this analysis, a final version of the CLD of this system was developed and is shown in Figure 14. This CLD serves as a basis from which the prioritisation of system driving factors could be performed and a weighted hierarchy of factors could be created.

4.2.2. Prioritisation of System Driving Factors using the HSIM Technique

To quantify the driving factors of a GBV system the Hybrid Structural Interaction Matrix (HSIM) technique was used as a weight-based modelling approach for driver prioritisation. The HSIM methodology is a problem-solving tool that has been used to solve social problems in the past by utilising the principle of subordination and various embedded features of hierarchical tree structure diagramming to actively engage in the interaction of system elements. This methodology is well-structured and matrix-oriented to easily represent all system elements in a pair-wise comparison. The factors listed below are considered:

1. Biological factors
2. Societal factors
3. Personal factors
4. Economic factors
5. Substance abuse
6. Religion and cultural practices
7. Age
8. Race

9. Sex
10. Mental health problems
11. Level of education
12. Income
13. Opportunity for economic advancement
14. Gender
15. Maltreatment at a young age
16. Witnessing violence between parents or caregivers
17. Controlling behaviour from parents or caregivers
18. Emotional bonding with parents
19. Exposure to poor parenting practices
20. Family dysfunction or separation
21. Family honour
22. Social and gender norms
23. Social protection for victims
24. Access to substances
25. Access to firearms
26. Social cohesion and unity
27. Gender equality
28. Levels of poverty
29. Income generation opportunities
30. Population densities
31. Legal action for sexual violence offences
32. Economic, educational and health policies
33. Normalisation of substance misuse
34. Sexual entitlement ideologies
35. Normalisation of violence and violent practices
36. Early or forced marriage
37. Multiple partners
38. Attitudes that disregard violence
39. Patriarchy
40. Pandemic and lockdown measures
41. Marital status
42. Health

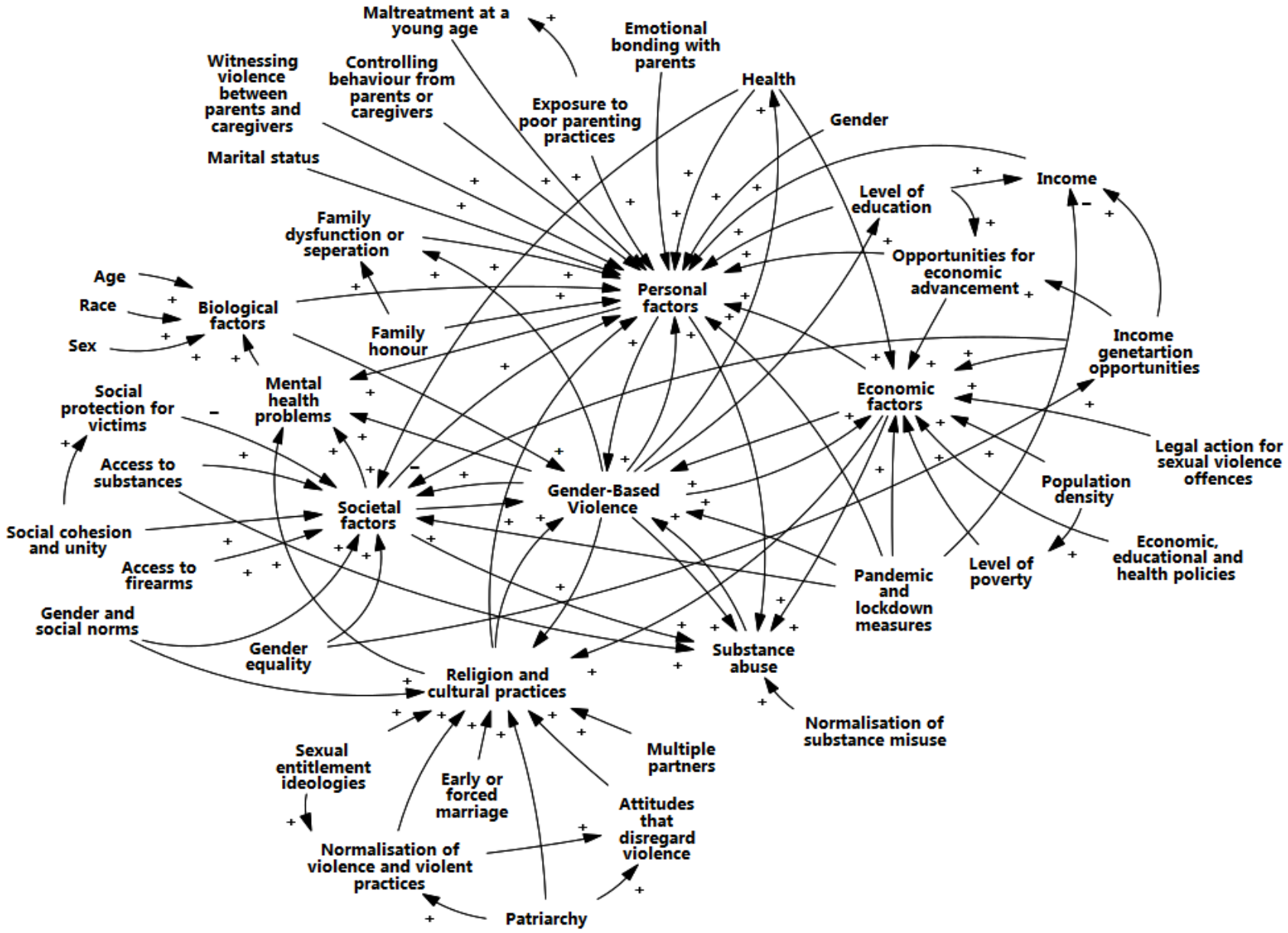

Figure 14: Complete CLD showing all GBV system drivers and relationships

The contextual relationship developed for the system under investigation asks "if system driver *i* is caused by or influenced by system driver j?". Mathematically this relationship is written as:

$$e_{ij} = \begin{cases} 1 \; if \; driver \; i \; is \; caused \; or \; influenced \; by \; driver \; j \\ 0 \; if \; driver \; i \; is \; not \; caused \; or \; influenced \; by \; driver \; j \end{cases}$$

Where *i* represents the row elements and *j* represents the column elements. The element e_{ij} represents a specific elemental space within the matrix in row *i* and column *j*.

When performing a pair-wise comparison of these system drivers, a "no response" to the question stated above attracts 0 for the specific elemental space whereas a "yes response" attracts 1. It should be noted that from this comparison if elemental space $e_{ij} = 1$, then $e_{ji} = 0$. Thus, if an interaction exists between system drivers *i* and *j*. These interactions are deduced from the CLD shown in Figure 14. Figure 15 below shows the HSIM pair-wise matrix developed for this system, displaying the various interactions between system drivers.

This matrix allows for the system drivers to be prioritised hierarchically based on the principle of subordination. The hierarchy displayed in Figure 16 is based on the results obtained from the HSIM matrix. The hierarchy depicted in the figure below presents system drivers, for the GBV system under investigation, prioritised using structured subordination to prioritise drivers in an order of descending importance. This hierarchy consists of eight priority levels. System driver 27, namely gender equality, is placed at the highest level of priority in this hierarchy. System drivers one and five, namely biological factors and substance abuse are found on the lowest level.

At the second hierarchical level, six system drivers are presented namely, Level of education, Pandemic and lockdown measures, Income generation opportunities, Population density, Sexual entitlement ideologies and patriarchy.

The third priority level includes Income, Opportunity for economic advancement, Legal action for sexual violence offences, Level of poverty, Economic, educational and health policies, Health, Normalisation of violence and violent practices and social cohesion and unity system drivers. At the fourth level of the hierarchy the following system drivers are present namely, Social and gender norms, Economic factors, Early and forced marriage, Multiple partners, Family honour, Social protection for victims, Access to substances and firearms, Marital status and Exposure to poor parenting practices

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	1	1	0	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1
4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	1	0	1
5	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0		
13	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0		
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0		
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0		
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0		
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Figure 15: HSIM pair-wise matrix

This priority level includes the most system drivers compared to the other priority levels. Level five on the hierarchy includes eight system drivers namely, Religion and cultural practices, Gender, Witnessing violence between parents or caregivers, Controlling behaviour from parents or caregivers, Emotional bonding with parents, Family dysfunction or separation, Personal factors and Maltreatment at a young age. Priority levels six and seven include the Societal factors, Normalisation of substance misuse, Mental health problems, Age, Race and Sex system drivers respectively.

An interesting observation made from this hierarchical diagram is that the primary system drivers appear on lower priority levels, with none of them being present in priority levels one,

two or three. The descending degree of importance/priority among the primary system drivers are as follows, Economic factors, Religion and cultural practices, Personal factors, Societal factors, Substance abuse and lastly Biological factors. Priority level two and three includes mostly system drivers that affect on the Economic factor's primary system driver. Priority level four includes mostly secondary system drivers which have an impact on the Societal factors and Religion and Cultural Practices primary system drivers. Priority level five includes system drivers affecting the Personal factors primary system driver while priority levels six and seven include secondary system drivers affecting mainly the Biological factors primary system driver. The shape that this hierarchy encompasses should also be noted. The majority of the system drivers fall in the middle range of priority levels namely priority levels two, three, four and five. Very few system variables are present in priority levels one and six through eight.

Figure 16 on the next page depicts the hierarchy developed for the defined GBV system.

4.2.3. Weight Determination for System Drivers

The model presented below was used to calculate the intensity of importance weighting of the prioritised system drivers. Developing and assigning intensity of importance ratings to system drivers depends on the number of subordinate system drivers to that specific driver. This serves as a basis for further numerical analysis within the GBV system. The values obtained for this model are presented in Table 12 and Table 13. Note that a scale rating ranging from 0 to 9 (assumed to represent the fundamental digits) was used.

$$I_{RFi} = \left\{\frac{N_{SFi}}{T_{NF}} \times M_{SR}\right\} + \left\{\frac{b}{T_{NF}}(M_{SR} - C)\right\} \text{ where } b = N_{SFi} + 1 \text{ and } C = \frac{M_{PSF}}{T_{NF}} \times M_{SR}$$

The mathematical notations used in this model is described as follows:

- I_{RFi} : the intensity of importance rating/weighting of driver *i*
- N_{SFi} : the number of subordinate drivers to a particular system driver *i*
- T_{NF} : the total number of system drivers
- M_{SR} : the maximum scale rating defined for this system
- M_{PSF} : the maximum number of possible subordinate system drivers
- C : a constant for the identified system
- $\frac{b}{T_{NF}}$: the variant ratio of the system

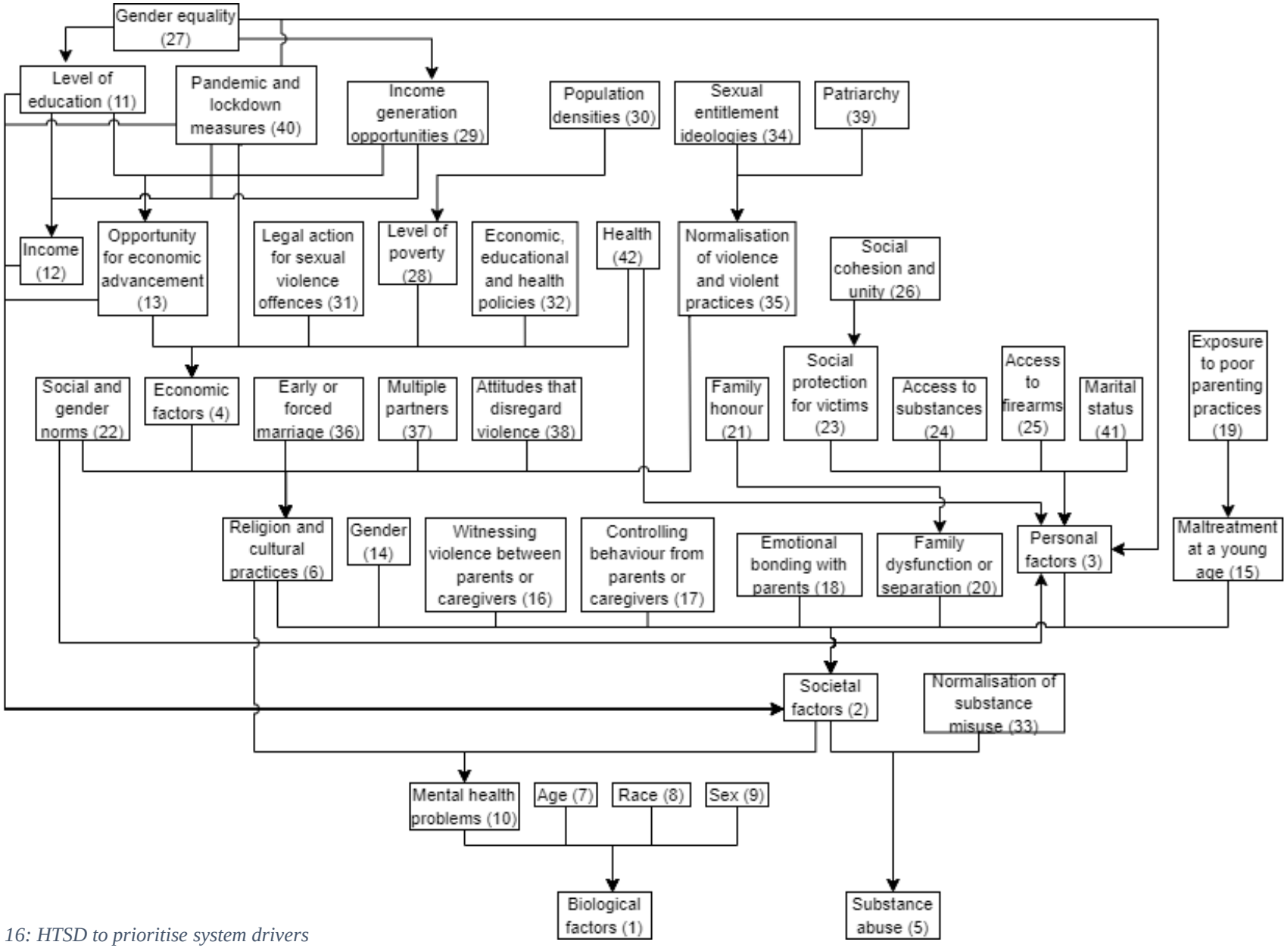

Figure 16: HTSD to prioritise system drivers

Table 12: Number of subordinate drivers for all system elements

Driver number	***Number of subordinate drivers***	***Driver number***	***Number of subordinate drivers***	***Driver number***	***Number of subordinate drivers***
1	0	15	4	29	8
2	3	16	4	30	7
3	4	17	4	31	6
4	5	18	4	32	6
5	0	19	5	33	1
6	4	20	4	34	6
7	1	21	5	35	5
8	1	22	6	36	5
9	1	23	5	37	5
10	1	24	5	38	5
11	8	25	5	39	6
12	4	26	6	40	8
13	6	27	11	41	5
14	4	28	6	42	7

Table 13: Intensity of importance rating for all system drivers

Driver number	N_{SFi}	M_{PSF}	T_{NF}	M_{SR}	C	b	I_{RFi}
1	0	41	42	9	8.785714	1	0.005102
2	3	41	42	9	8.785714	4	0.663265
3	4	41	42	9	8.785714	5	0.882653
4	5	41	42	9	8.785714	6	1.102041
5	0	41	42	9	8.785714	1	0.005102
6	4	41	42	9	8.785714	5	0.882653
7	1	41	42	9	8.785714	2	0.224489
8	1	41	42	9	8.785714	2	0.224489
9	1	41	42	9	8.785714	2	0.224489
10	1	41	42	9	8.785714	2	0.224489
11	8	41	42	9	8.785714	9	1.760204
12	4	41	42	9	8.785714	5	0.882653
13	6	41	42	9	8.785714	7	1.321429
14	4	41	42	9	8.785714	5	0.882653
15	4	41	42	9	8.785714	5	0.882653
16	4	41	42	9	8.785714	5	0.882653
17	4	41	42	9	8.785714	5	0.882653
18	4	41	42	9	8.785714	5	0.882653
19	5	41	42	9	8.785714	6	1.102041
20	4	41	42	9	8.785714	5	0.882653
21	5	41	42	9	8.785714	6	1.102041
22	6	41	42	9	8.785714	7	1.321429
23	5	41	42	9	8.785714	6	1.102041

Driver number	N_{SFi}	M_{PSF}	T_{NF}	M_{SR}	C	b	I_{RFi}
24	5	41	42	9	8.785714	6	1.102041
25	5	41	42	9	8.785714	6	1.102041
26	6	41	42	9	8.785714	7	1.321429
27	11	41	42	9	8.785714	12	2.418367
28	6	41	42	9	8.785714	7	1.321429
29	8	41	42	9	8.785714	9	1.760204
30	7	41	42	9	8.785714	8	1.540816
31	6	41	42	9	8.785714	7	1.321429
32	6	41	42	9	8.785714	7	1.321429
33	1	41	42	9	8.785714	2	0.224489
34	6	41	42	9	8.785714	7	1.321429
35	5	41	42	9	8.785714	6	1.102041
36	5	41	42	9	8.785714	6	1.102041
37	5	41	42	9	8.785714	6	1.102041
38	5	41	42	9	8.785714	6	1.102041
39	6	41	42	9	8.785714	7	1.321429
40	8	41	42	9	8.785714	9	1.760204
41	5	41	42	9	8.785714	6	1.102041
42	7	41	42	9	8.785714	8	1.540816

For the intensity of importance rating values to be useful during further system analysis and modelling, it was normalised in such a way that when summed it equals one. If the summed normalised weights equal one it makes it easier to express the relationship between system drivers as a ratio of proportionality. The normalisation performed for the intensity of importance ratings is shown in Table 14. N_{wi} denotes the normalised weighted values of the system drivers. The normalised values were used during further analysis.

Table 14: Normalised weighting of system drivers

Driver number	I_{RFi}	$(I_{RFi})^{1/n}$	N_{wi}	***Driver number***	I_{RFi}	$(I_{RFi})^{1/n}$	N_{wi}
1	0.005102	0.881906	0.021142	22	1.321429	1.006658	0.024132
2	0.663265	0.990272	0.023739	23	1.102041	1.002316	0.024028
3	0.882653	0.997032	0.023902	24	1.102041	1.002316	0.024028
4	1.102041	1.002316	0.024028	25	1.102041	1.002316	0.024028
5	0.005102	0.881906	0.021142	26	1.321429	1.006658	0.024132
6	0.882653	0.997032	0.023902	27	2.418367	1.021249	0.024482
7	0.224489	0.965056	0.023135	28	1.321429	1.006658	0.024132
8	0.224489	0.965056	0.023135	29	1.760204	1.013554	0.024298
9	0.224489	0.965056	0.023135	30	1.540816	1.010346	0.024221
10	0.224489	0.965056	0.023135	31	1.321429	1.006658	0.024132
11	1.760204	1.013554	0.024298	32	1.321429	1.006658	0.024132
12	0.882653	0.997032	0.023902	33	0.224489	0.965056	0.023135

Driver number	I_{RFi}	$(I_{RFi})^{1/n}$	N_{wi}	***Driver number***	I_{RFi}	$(I_{RFi})^{1/n}$	N_{wi}
13	1.321429	1.006658	0.024132	34	1.321429	1.006658	0.024132
14	0.882653	0.997032	0.023902	35	1.102041	1.002316	0.024028
15	0.882653	0.997032	0.023902	36	1.102041	1.002316	0.024028
16	0.882653	0.997032	0.023902	37	1.102041	1.002316	0.024028
17	0.882653	0.997032	0.023902	38	1.102041	1.002316	0.024028
18	0.882653	0.997032	0.023902	39	1.321429	1.006658	0.024132
19	1.102041	1.002316	0.024028	40	1.760204	1.013554	0.024298
20	0.882653	0.997032	0.023902	41	1.102041	1.002316	0.024028
21	1.102041	1.002316	0.024028	42	1.540816	1.010346	0.024221
Total summation of $(I_{RFi})^{1/n}$							41.713998
Total summation of N_{wi}							1.000000

4.2.4. Quantification of System Complexity

The main objective of quantifying the systems' complexity is ultimately to be able to provide different methods that can be used to control the impact that this system has on various individuals affected by it and to develop effective problem-solving methods specific to this system. By quantifying the complexity of the GBV system under investigation an increased understanding was developed by comparing the degree of impact of the different system drivers.

The normalised weighted values were used to assess and analyse the possible quantitative impact of the system drivers and their effects on the victims/society at large. This was done using a spider/radar diagram as seen in Figure 17 on the next page and was created on Microsoft Excel. The system drivers were plotted on a scale of 0 to 0.028. This was the most suitable range as the weighted values are small due to the number of drivers identified for the system.

The surface area of the graph covers a large area showing that the GBV system under investigation is complex and that it has a significant impact on individuals in contact with it. To reduce the total impact of this system on its victims or other members of society, each system driver needs to be individually addressed and measures for it developed to reduce its impact. Each spoke on the spider diagram represents a system driver. The normalised weighted values calculated during earlier stages of analysis was used as input value to this diagram when plotting a system driver on a spoke. These system drivers are related to one another on the graph, as they are grouped based on the primary system driver that they are assigned to.

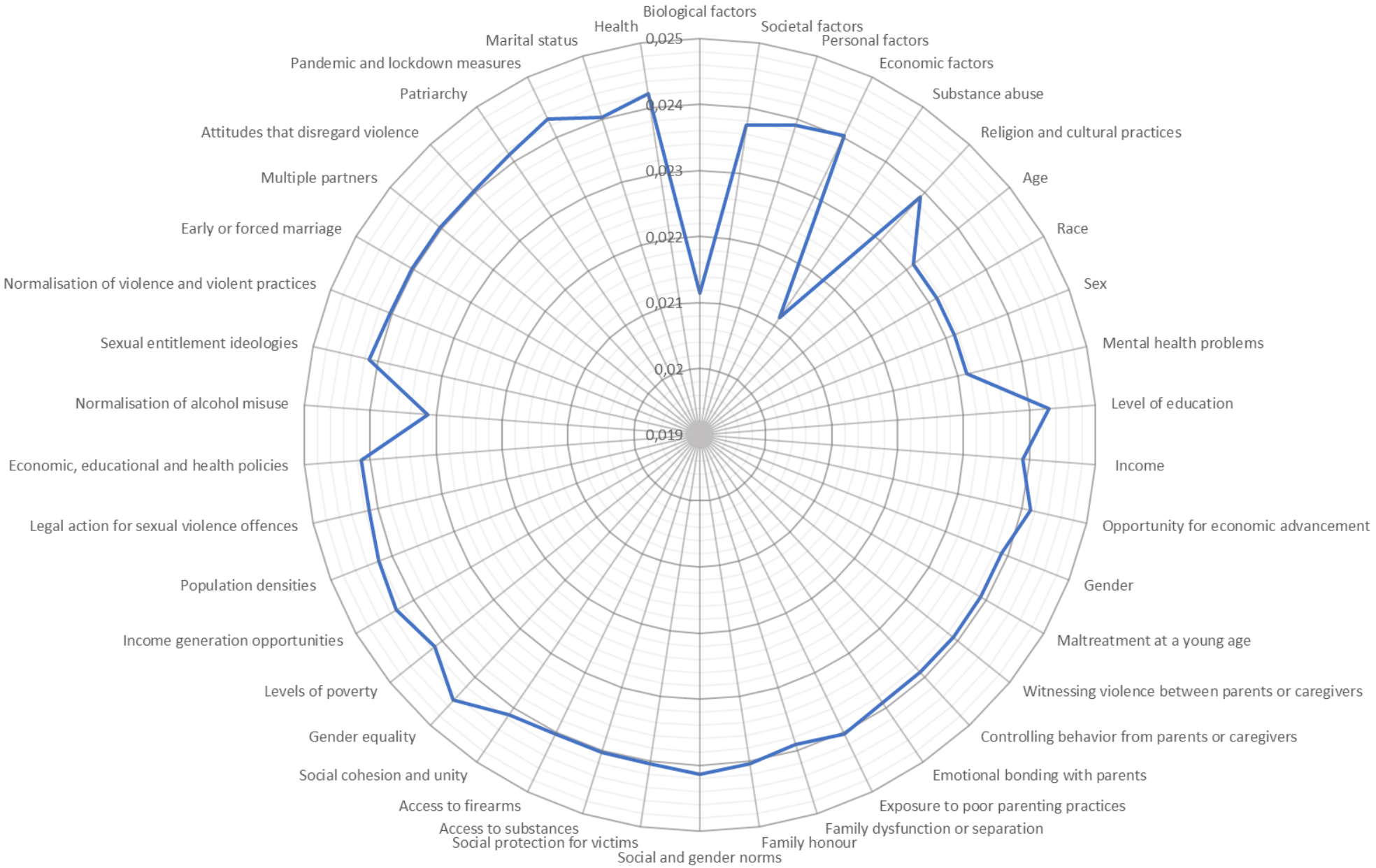

Figure 17: Spider Diagram showing GBV baseline system complexity

The centre of this diagram represents the zero mark. The quantity that each system driver encompasses increases the further down toward the edge of the spoke it is plotted. Most of the system drivers lie more or less within the same value range. The system drivers' values that stand out and are higher than the rest, include level of education, gender equality, pandemic and lockdown measures and health. System drivers whose values are lacking and lower than the rest of the drivers on the diagram include substance abuse, normalisation of substance misuse, age, race, sex and mental health problems.

To determine the degree of complexity of this system, the values of random system variables were altered and compared against the base complexity level depicted in Figure 17. This method was followed for three iterations, changing the values of ten randomly selected system drivers. The value of each system driver was altered/reduced by a random factor of 0.2 of its original value (i.e. $original\ value - (0.2 \times original\ value)$. System drivers were randomly selected using Excel's *RANDBETWEEN()* function, selecting random values between one and 42 (to account for all system drivers). The variables selected, new values used and complexity score for each iteration are provided in Table 15 below.

Table 15: Iterations to determine system complexity

System driver	***Original value***	***New value***
Iteration 1		
Normalisation of violence and violent practices	0.024028	0.019222
Health	0.024221	0.019377
Opportunity for economic advancement	0.024132	0.019306
Race	0.023135	0.018508
Controlling behaviour from parents or caregivers	0.023902	0.019123
Substance abuse	0.021142	0.016914
Attitudes that disregard violence	0.024028	0.019222
Emotional bonding with parents	0.023902	0.019123
Religion and cultural practices	0.023902	0.019123
Gender	0.023902	0.019123
Iteration 2		
Patriarchy	0.024132	0.019306
Sex	0.023135	0.018508
Gender and social norms	0.024132	0.019306
Age	0.023135	0.018508
Family honour	0.024028	0.019222
Early or forced marriage	0.024028	0.019222
Societal factors	0.023739	0.018991
The marital status	0.024028	0.019222
Normalisation of violence and violent practices	0.024028	0.019222
Gender	0.023902	0.019123

Iteration 3		
Witnessing violence between parents and caregivers	0.023902	0.019123
Access to substances	0.024028	0.019222
Family honour	0.024028	0.019222
Social cohesion and unity	0.024132	0.019306
Biological factors	0.021142	0.016914
Age	0.023135	0.018508
Legal action for sexual violence offences	0.024132	0.019306
Social protection for victims	0.024028	0.019222
Level of poverty	0.024132	0.019306
Economic factors	0.024028	0.019222

The Spider diagrams developed for each iteration is shown in Figure 18 to Figure 20. These iterations allow for a complexity score of the system to be developed against the baseline complexity. The values of all system drivers are summed for each iteration and divided by the summation of the original baseline values. This value is multiplied by 100 to get a final complexity score as a percentage. The complexity calculations are provided in below.

Complexity score for Iteration 1: $Complexity\ score = \frac{0.952748}{1} \times 100 = 95.2748\%$

Complexity score for Iteration 2: $Complexity\ score = \frac{0.952341}{1} \times 100 = 95.2341\%$

Complexity score for Iteration 3: $Complexity\ score = \frac{0.952662}{1} \times 100 = 95.2662\%$

These complexity scores illustrate that the impact of this GBV system on society at large can be decreased if the necessary time and resources are devoted to reducing the individual effect of the system drivers on the system itself. The complexity score of the system decreases even though all system variables are not addressed. This complexity analysis illustrates that the complexity of the GBV system will remain high if no mitigating actions or intervention measures are taken to address it. With this complexity analysis, it is possible to motivate that when appropriate solution mechanisms are introduced and applied to the GBV system to address either the output of the system as a whole or its drivers will be effective in reducing the complexity level. When no means of intervention is applied to the GBV system, the position of each system driver will be at the outermost part of this graph. Once intervention measures are introduced to reduce the impact of a system driver, the graph will converge more toward the centre of the diagram, thus minimising the total complexity of the system. The more variables that are addressed at once or the higher the degree of reduction of the impact of each system driver, the greater the effect on the system and decreasing the complexity.

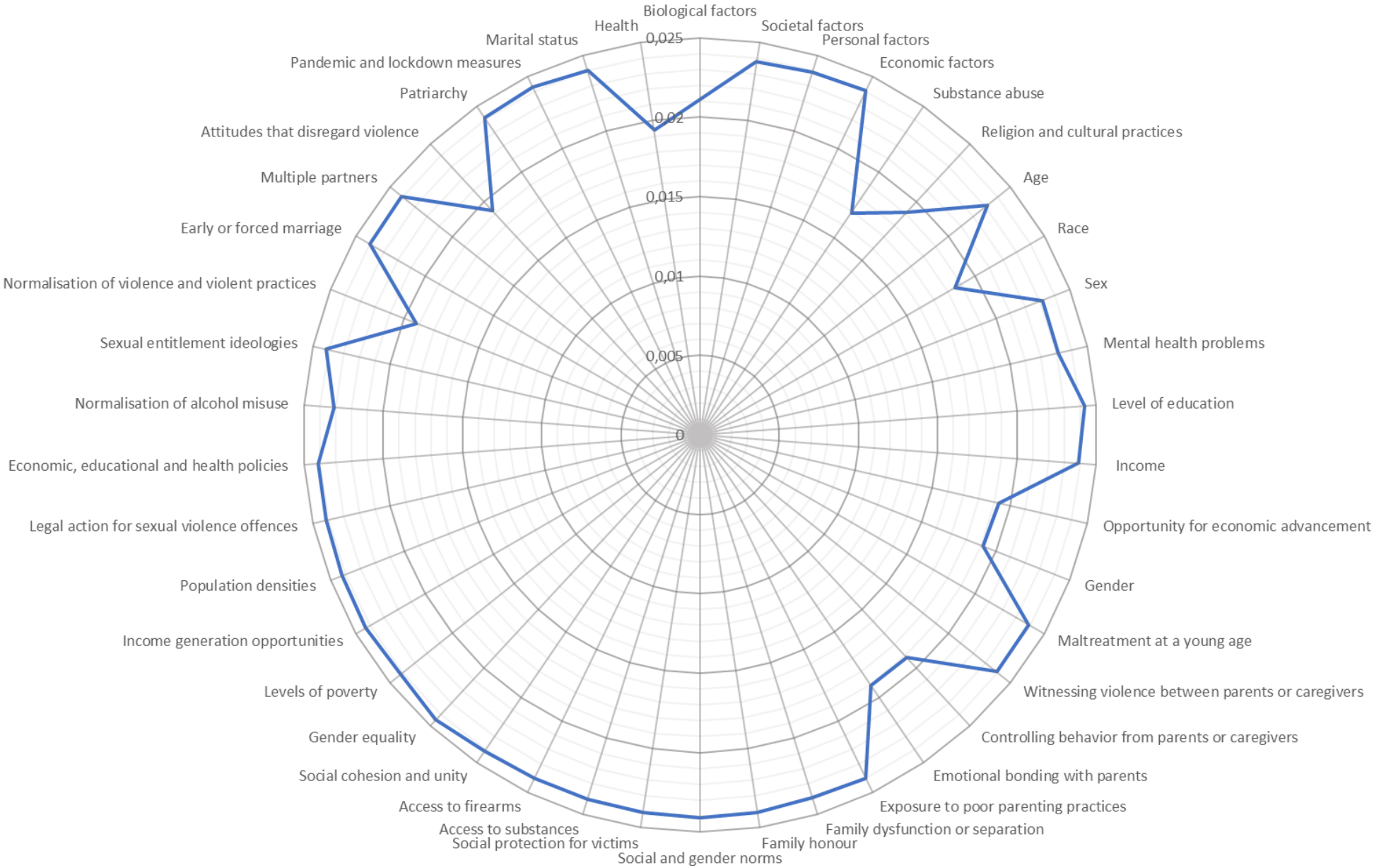

Figure 18: Spider Diagram showing GBV system complexity for Iteration 1

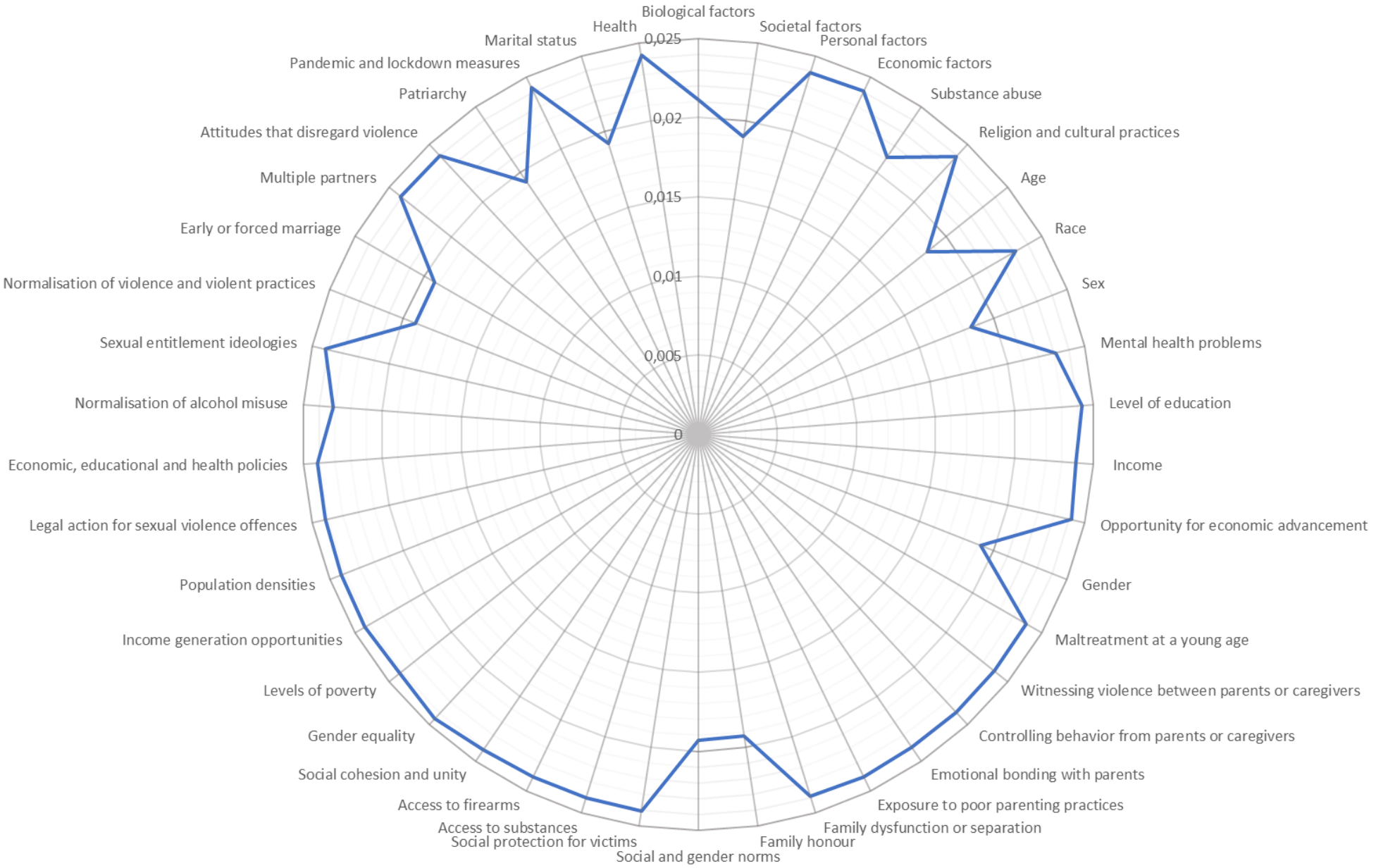

Figure 19: Spider Diagram showing GBV system complexity for Iteration 2

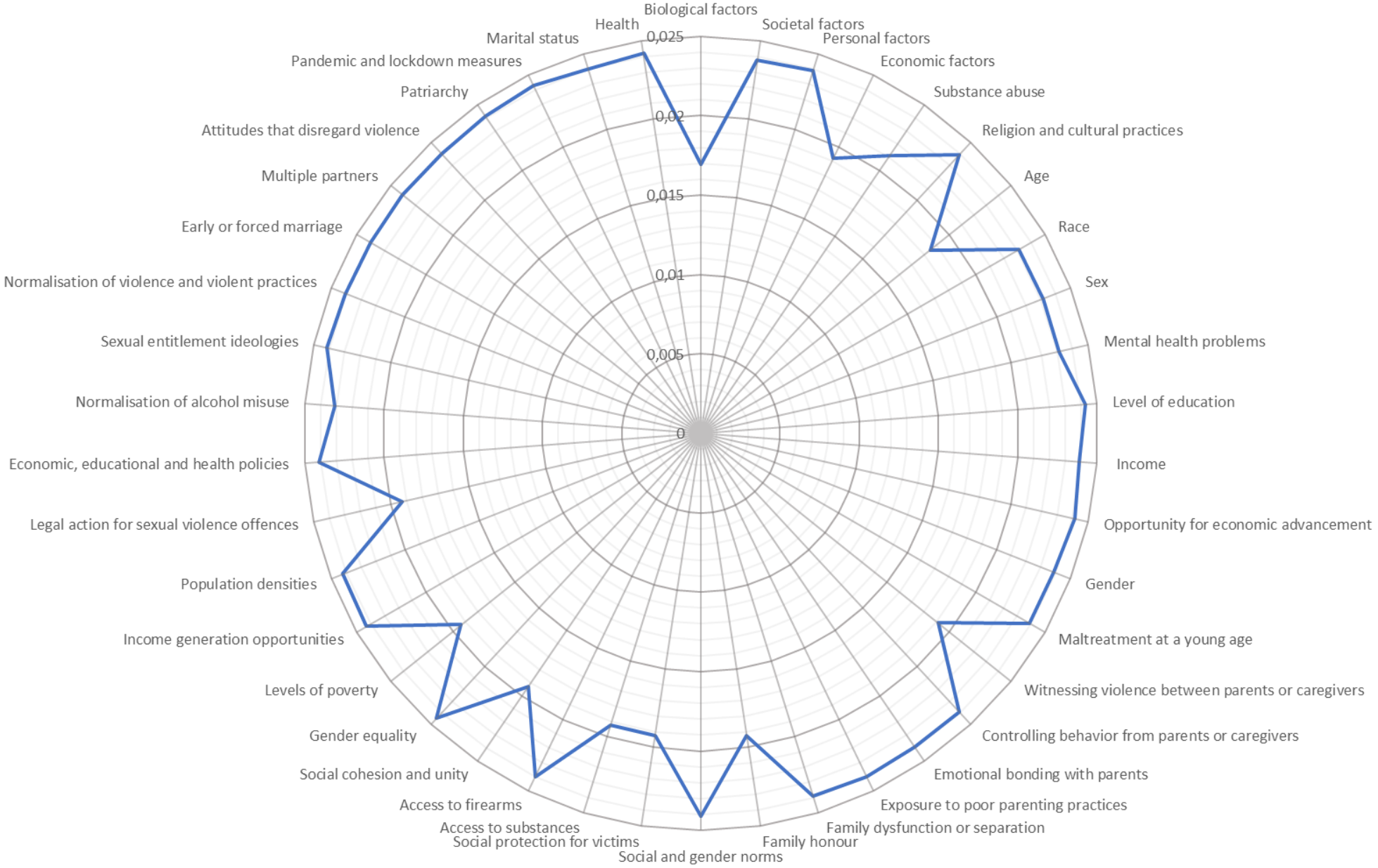

Figure 20: Spider Diagram showing GBV system complexity for Iteration 3

4.2.5. System Dynamics Modelling using a Stock and Flow Diagram

The Stock and Flow diagram presented in this section was used to represent the defined GBV system structure in more detail than its associated CLD. This Stock and Flow diagram was created on Vensim PLE. Extracts of the code used to run the initial simulations are presented in Appendix B.

A Stock and Flow diagram is normally used to understand the interactive dynamics that exist amongst the different interacting elements. Generally, system dynamics is used to study the structure and behaviour of systems. From this diagram, it is possible to obtain more detailed information about the GBV system via different simulation runs. The identified system drivers were classified as either Stock variables or Flow variables.

Stock variables (or Level variables) indicate the available or accumulated quantity or state of a variable at a specific point in time. The value of a stock variable depends on a specific instance and not the duration or passing of time. Stock variables are static and have no time dimension associated with them. Flow variables (or Rate variables) refer to variables that can be measured/changed over a while. The period over which these variables are measured is specific to and different from one system to the next. Flow variables are dynamic variables and have a time dimension associated with them. Flow variables influence stock variables.

The system drivers classified as stock and Flow variables respectively are stated below.

- ***Stock variables:*** Primary system drivers
- ***Flow variables:*** Secondary system drivers

This classification was done for the specific nature of the defined GBV system under investigation. The primary system drivers are classified as Stock variables, as one wants to measure those particular drivers in an individual (be it a victim or a perpetrator) at a specific moment in time. This is done to determine the likelihood that an individual will be exposed to or perpetrate GBV offences (thus whether an individual is susceptible to/influenced by GBV). The secondary system drivers are classified as Flow variables, as they influence the behaviour of the primary system drivers and ultimately the behaviour of the system. These variables are measured over a while.

The Stock and Flow diagram developed for this system is shown in Figure 21 on the next page. Two simulation runs showing the GBV systems' behaviour were executed utilising this Stock and Flow diagram. The simulation runs include a poorly managed and better-managed case scenario of system behaviour. These scenarios are described in the sections that follow.

During these simulation runs default weight assignment was used per driving factor. These weights are the normalised weighted values that were calculated earlier in the analysis and presented in Table 14. These weights are more of symbolic representation than actual data of the real event. Hence, when a factor is not being deployed with its full weighted value, it could imply a bad scenario or a better scenario as some factors are being minimised while others are being maximised. It could also be that a most likely range of values is used during the simulation rather than its extremities.

Data and equations used during the two case scenario simulation runs are presented in the tables afterwards. The *RANDOM.UNIFORM(m, x, s)* Vensim function was used during simulation where *m* represents the minimum value, *x* the maximum value and *s* the seed value. This function yields a uniform distribution between the minimum and maximum values, omitting the endpoints. The maximum values used in this simulation run are the normalised weighted values developed during earlier phases of analysis. These normalised weighted values are classified as the maximum or most extreme values that a specific variable can adopt. This specific system would aim to reduce the level or degree of GBV on an individual. A seed value of 0.001 was used in all simulation runs and represents the interval of change in value during the simulation run. Note that a default time of 100 months was used during the simulation.

Note that the numbers used in the different tables during all simulation and sensitivity analysis scenarios are used mostly as indicators and do not represent actual data of occurrence or exhibition of the system factors. The graphs presented throughout the simulations and sensitivity analyses are also explained from the point of view of indicator performance. Indicators are symbolic i.e. telling us if the situation is getting worse or better.

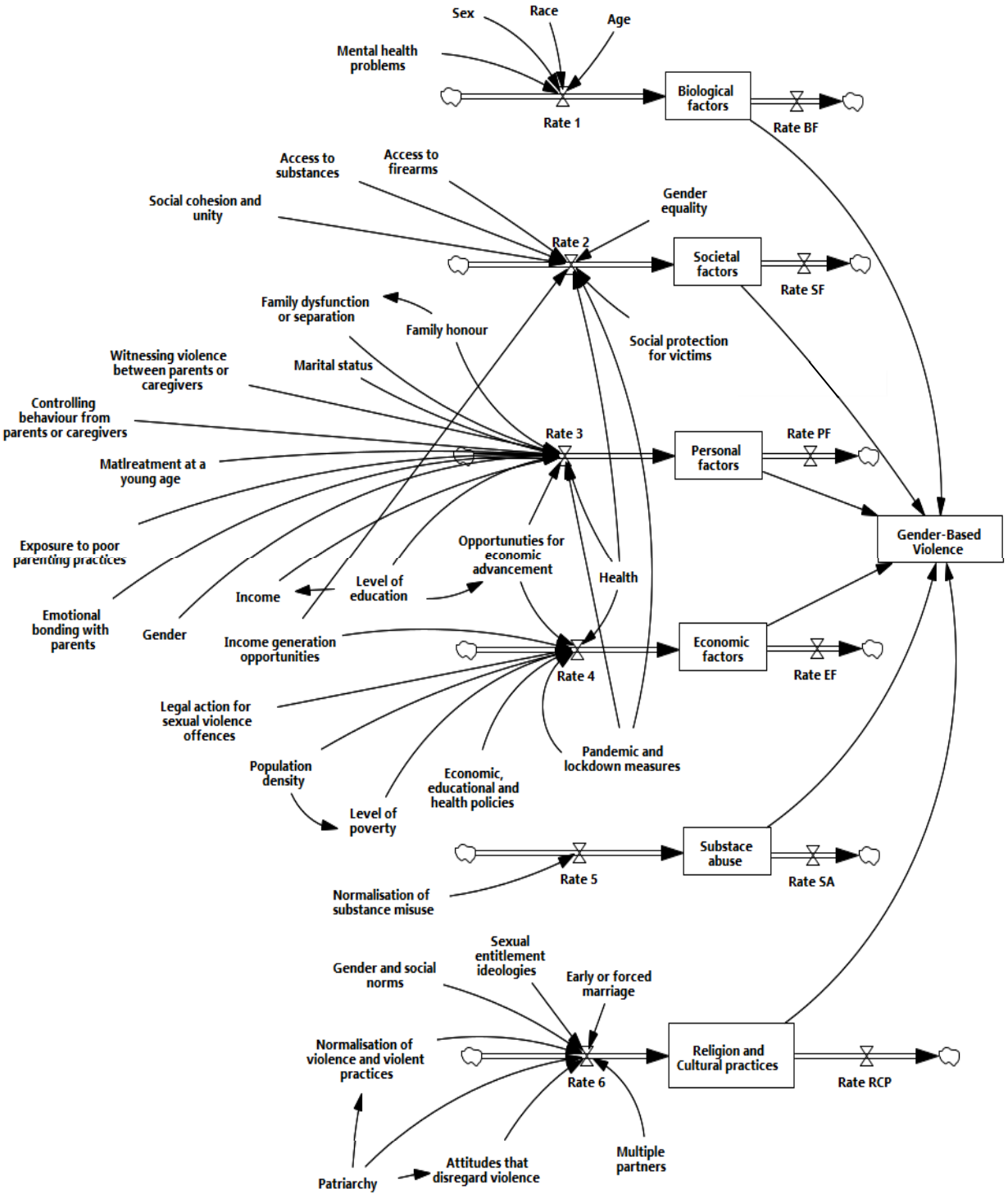

Figure 21: Stock and Flow diagram of the GBV system

4.5.1.1. Better-Managed Case Scenario Simulation Run

This simulation run represents the better-managed scenario for the defined GBV system, as it seeks to decrease the impact of GBV on an individual. This is done by setting the maximum value to zero. The minimum values used are the negative form of the normalised weighted values developed for each system driver. This negative value is used as it represents the same distance from zero as a positive value would.

Table 16: Better-managed case scenario data and equations

	Driver no.	***System driver***	***Equation***
Stock Variables		Gender-Based Violence	(Biological factors + Societal factors + Personal factors + Economic factors + Substance abuse + Religion and Cultural practices)/6
	1	Biological factors	Rate 1 – Rate BF
	2	Societal factors	Rate 2 – Rate SF
	3	Personal factors	Rate 3 – Rate PF
	4	Economic factors	Rate 4 – Rate EF
	5	Substance abuse	Rate 5 – Rate SA
	6	Religion and Cultural practices	Rate 6 – Rate RCP
Flow variables	7	Age	RANDOM.UNIFORM(-0.023135, 0, 0.001)
	8	Race	RANDOM.UNIFORM(-0.023135, 0, 0.001)
	9	Sex	RANDOM.UNIFORM(-0.023135, 0, 0.001)
	10	Mental health problems	RANDOM.UNIFORM(-0.023135, 0, 0.001)
	11	Level of education	RANDOM.UNIFORM(-0.024298, 0, 0.001)
	12	Income	RANDOM.UNIFORM(-0.023902, 0, 0.001)
	13	Opportunity for economic advancement	RANDOM.UNIFORM(-0.024132, 0, 0.001)
	14	Gender	RANDOM.UNIFORM(-0.023902, 0, 0.001)
	15	Maltreatment at a young age	RANDOM.UNIFORM(-0.023902, 0, 0.001)
	16	Witnessing violence between parents or caregivers	RANDOM.UNIFORM(-0.023902, 0, 0.001)
	17	Controlling behaviour from parents or caregivers	RANDOM.UNIFORM(-0.023902, 0, 0.001)
	18	Emotional bonding with parents	RANDOM.UNIFORM(-0.023902, 0, 0.001)
	19	Exposure to poor parenting practices	RANDOM.UNIFORM(-0.024028, 0, 0.001)
	20	Family dysfunction or separation	RANDOM.UNIFORM(-0.023902, 0, 0.001)
	21	Family honour	RANDOM.UNIFORM(-0.024028, 0, 0.001)
	22	Social and gender norms	RANDOM.UNIFORM(-0.024132, 0, 0.001)

	Driver no.	*System driver*	*Equation*
	23	Social protection for victims	RANDOM.UNIFORM(-0.024028, 0, 0.001)
	24	Access to substances	RANDOM.UNIFORM(-0.024028, 0, 0.001)
	25	Access to firearms	RANDOM.UNIFORM(-0.024028, 0, 0.001)
	26	Social cohesion and unity	RANDOM.UNIFORM(-0.024132, 0, 0.001)
	27	Gender equality	RANDOM.UNIFORM(-0.024482, 0, 0.001)
	28	Level of poverty	RANDOM.UNIFORM(-0.024132, 0, 0.001)
	29	Income generation opportunities	RANDOM.UNIFORM(-0.024298, 0, 0.001)
	30	Population density	RANDOM.UNIFORM(-0.024221, 0, 0.001)
	31	Legal action for sexual violence offences	RANDOM.UNIFORM(-0.024132, 0, 0.001)
	32	Economic, educational and health policies	RANDOM.UNIFORM(-0.024132, 0, 0.001)
	33	Normalisation of substance misuse	RANDOM.UNIFORM(-0.023135, 0, 0.001)
	34	Sexual entitlement ideologies	RANDOM.UNIFORM(-0.024132, 0, 0.001)
	35	Normalisation of violence and violent practices	RANDOM.UNIFORM(-0.024028, 0, 0.001)
	36	Early or forced marriage	RANDOM.UNIFORM(-0.024028, 0, 0.001)
	37	Multiple partners	RANDOM.UNIFORM(-0.024028, 0, 0.001)
	38	Attitudes that disregard violence	RANDOM.UNIFORM(-0.024028, 0, 0.001)
	39	Patriarchy	RANDOM.UNIFORM(-0.024132, 0, 0.001)
	40	Pandemic and lockdown measures	RANDOM.UNIFORM(-0.024298, 0, 0.001)
	41	Marital status	RANDOM.UNIFORM(-0.024028, 0, 0.001)
	42	Health	RANDOM.UNIFORM(-0.024221, 0, 0.001)

The results of the better-managed case scenario simulation run are illustrated in Figure 22. The rate of GBV in a better-managed GBV system decreases and illustrates the trend that one would expect from the output of this scenario. This graph shines a positive light on the GBV system under investigation and shows that there is a potential to change the way that GBV impacts and affects an individual for the better. This graph represents the state of GBV based off the data from Table 16. No external influences, such as prevention strategies or mitigation attempts are present during this simulation run. Over a 100-month period the number of GBV incidents against individuals, decreases by 179.427 incidents.

This graph represents the ideal better-managed case scenario for the GBV system under study if it is left as is without any additional means of intervention. This is however not the most ideal scenario that this system can encompass, as the degree of positive change on not only the

system itself, but also the individuals impacted by it could be even greater if additional external means of prevention and intervention were to be implemented into the system. Note that no labels are assigned to the y-axis on the system output graphs presented in this chapter. The exact number of GBV cases are not measured during this study, but rather the values presented on this axis indicate the system behavior and serve as means of obtaining improved insight into the system.

Figure 22: Better-managed case scenario system output

4.5.1.2. Poorly Managed Simulation Run

In the poorly managed simulation run presented below the most probable range of values, that each respective system driver can encompass was identified and used. This most probable range is illustrated in Figure 23. Each normalised weighted value was divided into quartiles, where quartile two (Q2) represents the median. Quartile one (Q1) and quartile three (Q3) represent 25% and 75% of the data respectively. As it is unlikely that the value of a system driver will encompass one of its extreme values in reality, the range of values between Q1 and Q3 are used for this simulation run.

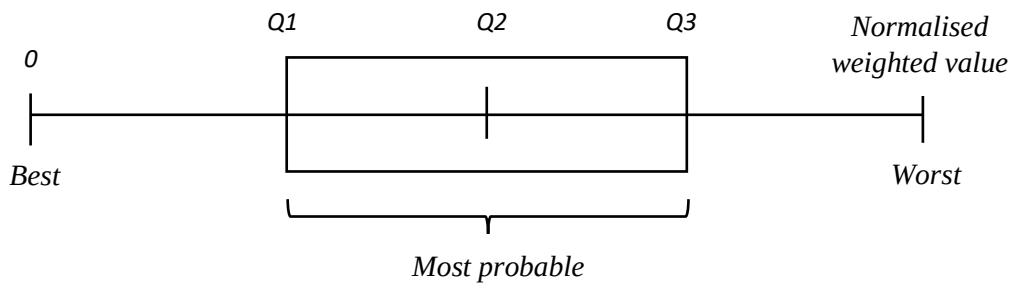

Figure 23: Most probable value range utilising quartiles

Table 17 presents the data used during the poorly managed simulation run. The results of the final output in this simulation run are shown in Figure 24.

Table 17: Poorly managed case scenario simulation data and equations

	Driver no.	***System driver***	***Equation***
Flow variables	7	Age	RANDOM.UNIFORM(0.005784, 0.017351, 0.001)
	8	Race	RANDOM.UNIFORM(0.005784, 0.017351, 0.001)
	9	Sex	RANDOM.UNIFORM(0.005784, 0.017351, 0.001)
	10	Mental health problems	RANDOM.UNIFORM(0.005784, 0.017351, 0.001)
	11	Level of education	RANDOM.UNIFORM(0.006074, 0.018223, 0.001)
	12	Income	RANDOM.UNIFORM(0.005975, 0.017926, 0.001)
	13	Opportunity for economic advancement	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)
	14	Gender	RANDOM.UNIFORM(0.005975, 0.017926, 0.001)
	15	Maltreatment at a young age	RANDOM.UNIFORM(0.005975, 0.017926, 0.001)
	16	Witnessing violence between parents or caregivers	RANDOM.UNIFORM(0.005975, 0.017926, 0.001)
	17	Controlling behaviour from parents or caregivers	RANDOM.UNIFORM(0.005975, 0.017926, 0.001)
	18	Emotional bonding with parents	RANDOM.UNIFORM(0.005975, 0.017926, 0.001)
	19	Exposure to poor parenting practices	RANDOM.UNIFORM(0.006007, 0.018021, 0.001)
	20	Family dysfunction or separation	RANDOM.UNIFORM(0.005975, 0.017926, 0.001)
	21	Family honour	RANDOM.UNIFORM(0.006007, 0.018021, 0.001)
	22	Social and gender norms	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)
	23	Social protection for victims	RANDOM.UNIFORM(0.006007, 0.018021, 0.001)
	24	Access to substances	RANDOM.UNIFORM(0.006007, 0.018021, 0.001)
	25	Access to firearms	RANDOM.UNIFORM(0.006007, 0.018021, 0.001)
	26	Social cohesion and unity	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)

	Driver no.	*System driver*	*Equation*
	27	Gender equality	RANDOM.UNIFORM(0.006121, 0.018362, 0.001)
	28	Level of poverty	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)
	29	Income generation opportunities	RANDOM.UNIFORM(0.006074, 0.018223, 0.001)
	30	Population density	RANDOM.UNIFORM(0.006055, 0.018166, 0.001)
	31	Legal action for sexual violence offences	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)
	32	Economic, educational and health policies	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)
	33	Normalisation of substance misuse	RANDOM.UNIFORM(0.005784, 0.017351, 0.001)
	34	Sexual entitlement ideologies	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)
	35	Normalisation of violence and violent practices	RANDOM.UNIFORM(0.006007, 0.018021, 0.001)
	36	Early or forced marriage	RANDOM.UNIFORM(0.006007, 0.018021, 0.001)
	37	Multiple partners	RANDOM.UNIFORM(0.006007, 0.018021, 0.001)
	38	Attitudes that disregard violence	RANDOM.UNIFORM(0.006007, 0.018021, 0.001)
	39	Patriarchy	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)
	40	Pandemic and lockdown measures	RANDOM.UNIFORM(0.006074, 0.018223, 0.001)
	41	Marital status	RANDOM.UNIFORM(0.006007, 0.018021, 0.001)
	42	Health	RANDOM.UNIFORM(0.006055, 0.018166, 0.001)

Figure 24 illustrates that the system of GBV and its effect on an individual will, in its most likely poorly managed current state, continue to steadily increase if no additional mitigation measures or prevention interventions are implemented. The increase in this simulation run shows an exponential increase ultimately ending at 9.51424 more incidents against an individual over 100 months. This should raise concern among not only people affected by GBV but also among other members of a community or society, as the problem that GBV currently pose for them will become even greater in years to come. It is important to identify areas within the system (specifically among the system flow variables) where prevention attempts can be

implemented to change the output of not only GBV but also of the various stock variables in the system.

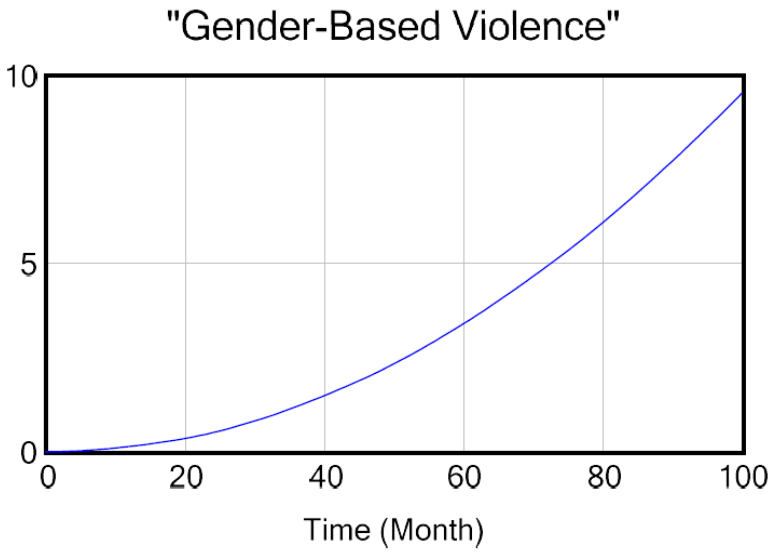

Figure 24: Poorly managed case scenario system output

It is important to perform a sensitivity analysis on the GBV system under investigation, not only to validate the reliability of the different simulation runs' results, but also because the various flow variables serving as system inputs are subject to uncertainty.

Sensitivity analysis studies the impact that a change (either in magnitude or nature) of a system input variable(s) has on the final system output, under a predefined set of assumptions. During a sensitivity analysis, the decision-maker is generally interested in determining how much the system input values need to be varied to produce a variation in the final system output.

4.2.6. Sensitivity Analysis

To perform a sensitivity analyses the kind of probability distribution values to be used for the different system variables should be determined, the simplest of which being the Random Uniform Distribution (as used in the three simulation runs in the previous section), where any number ranging between the minimum and maximum values (differing in each simulation run scenario) are equally likely to take place.

In this section, a sensitivity analysis is performed in three different ways to show what the impact of this sensitivity analysis would be on the final system output. These include studying the change that system input variables (in this case flow variables/secondary system drivers) has on GBV in isolation, the effect that changes in groups of input variables have on GBV and

finally the effect that changing system flow variables with the highest normalised weighted values has on the GBV system.

Variables identified as areas where a positive system change can be observed are areas where more resources (in the form of time, money, prevention strategies or mitigation attempts) should be implemented to ultimately, over time, change the effect that GBV has on individuals and society. These variables are identified in the various sensitivity analyses below.

4.2.6.1. Sensitivity Analysis 1: Changing Flow Variables with the Highest Normalised Weighted Values

In the first sensitivity analysis of the defined GBV system, the six system flow variables with the highest weighted normalised values are considered. In an ideal setting, one should seek to decrease the weight that these variables carry within the GBV system, as these variables should theoretically have the greatest impact on the system itself. This sensitivity analysis, looks to determine if these changes would have a positive effect on the final output of the GBV system.

The six flow variables (secondary system drivers) with the highest determined normalised weighted values are listed along with their respective weights:

- System driver 27: *Gender equality* (normalised weighted value of *0.024482*)
- System driver 11: *Level of education* (normalised weighted value of *0.024298*)
- System driver 29: *Income generation opportunities* (normalised weighted value of *0.024298*)
- System driver 40: *Pandemic and lockdown measures* (normalised weighted value of *0.024298*)
- System driver 30: *Population density* (normalised weighted value of *0.024221*)
- System driver 42: *Health* (normalised weighted value of *0.024221*)

Changes to these system drivers were made across both simulation run scenarios. This is done to determine if a positive change can be observed over all scenarios. The changes made and results obtained from each of these scenarios are presented below.

The first scenario used in this analysis is the *poorly managed* scenario. In this analysis the range of values between which each variable could fluctuate was decreased by 25% of its original value (as was used during the simulation run). The minimum value was thus changed to zero and the maximum value to the Quartile 2 (Q2) value during the analysis. Table 18 below presents the new data used during the simulation for these six variables. Note that the data for all other system variables remain unchanged.

Table 18: Sensitivity Analysis 1 new data and equations for the Poorly managed case scenario

Variable/driver	***Original equation***	***New equation***
Gender equality	RANDOM.UNIFORM(0.006121, 0.018362, 0.001)	RANDOM.UNIFORM(0, 0.012242, 0.001)
Level of education	RANDOM.UNIFORM(0.006074, 0.018223, 0.001)	RANDOM.UNIFORM(0, 0.012148, 0.001)
Income generation opportunities	RANDOM.UNIFORM(0.006074, 0.018223, 0.001)	RANDOM.UNIFORM(0, 0.012148, 0.001)
Pandemic and lockdown measures	RANDOM.UNIFORM(0.006074, 0.018223, 0.001)	RANDOM.UNIFORM(0, 0.012148, 0.001)
Population density	RANDOM.UNIFORM(0.006055, 0.018166, 0.001)	RANDOM.UNIFORM(0, 0.012110, 0.001)
Health	RANDOM.UNIFORM(0.006055, 0.018166, 0.001)	RANDOM.UNIFORM(0, 0.012110, 0.001)

From the sensitivity analysis simulation, it is noted that the fluctuation range for each of these system drivers has changed and had decreased. The degree of fluctuation has however remained the same, due to the nature of the simulation set-up.

Gender equality plays an important role in GBV within a society or community. It is argued that low levels of gender equality in society cause higher levels of violence tolerance and can lead to higher levels of GBV and other forms of violent behaviour being directed against the societies' members. The United Nations Women state that violence prevention should start during the earliest possible life stages, by promoting concepts such as respect for fellow human beings and gender equality among children. The UN Women also argue that these early stages of a person's life are often overlooked but are crucial to promoting positive gender equality values and norms. Therefore, if a society allocates the required resources including money and time, and implementing mitigation or prevention measures it is possible to reduce the impact that this variable has in the bigger system of GBV and the individuals affected by it.

Education and income generation opportunities are beneficial to one another and can be studied in conjunction. By reducing the number of individuals who do not have an education or the necessary educational opportunities, the number of individuals who do not have any means or opportunity to generate income within that society will also decrease.

Providing all individuals within a society or community with appropriate opportunities to receive good quality education and learning opportunities can have a positive effect on not only an individual, but also on the society or community itself. Literature shows that individuals (especially women) who depend on an abusive partner are more likely to tolerate violent

behaviour and stay in an abusive relationship. A need exists for improved education opportunities to be provided to young girls and women. This will enable them to leave violent relationships and allows them to establish a better life for themselves within society by becoming economically independent. Therefore, any small changes made, like that of providing proper educational opportunities to all individuals, provide them with more economic opportunities and ultimately a means of generating income.

The role that women play within a society or community has been normalised over many years and places them at a disadvantage. Efforts should be made to educate men and young boys on topics such as GBV and gender equality. This small change can change how boys and men perceive women and girls, gender norms and equality and ultimately GBV. It can also lead to increased levels of respect between individuals of opposite gender and ultimately reduce violence and violent behaviour in relationships.

The recent Covid-19 pandemic posed a big threat to women and girls across the world. Studies argue that women found themselves trapped between two pandemics and during the pandemic period a sharp increase could be observed in the number of GBV and abuse cases. Many interventions and prevention measures exist to fight GBV and support its victims. These measures have however not been as successful as may have been intended, especially during the pandemic period, when what the world thought was normal suddenly changed. If these prevention attempts had been successful or implemented correctly, the increase in GBV cases during the pandemic may have been less severe. Therefore, resources need to be allocated and mitigation attempts must be developed and set in place to ensure that if a similar situation occurs, it can be effectively dealt with and that the effect of this variable within the system can be reduced.

Population density within a community or society poses a threat to the availability of economic advancement opportunities for individuals who live there. When population levels are too high within certain societies, the number of work opportunities and thus a means of income may be limited. When these opportunities are limited or scarce it can make it difficult for individuals who depend on others to become economically or financially independent. By reducing the effect that this variable has on the bigger system of GBV in conjunction with the other flow variables discussed in this Section, a positive result can be observed in the system.

The health of GBV victims is often impacted by a lacking healthcare system or by the victim's unwillingness to report the incident or seek help. Victims of GBV are reluctant to seek medical

help for the injuries that they sustain due to the fear of being rejected by their communities and the stigma associated with it. These victims often seek informal means of help from their close networks (including their family members, friends or other members of the community).

Healthcare providers also fail/struggle to diagnose, treat and register incidents of GBV, due to a lack of awareness about the impact and effect of GBV and a lack of knowledge of this field. Healthcare workers also struggle to effectively care for GBV victims due to poor clinical practices within their work environment, limiting their ability to fully examine their patients, register and document these incidents and communicate this type of violence through the correct channels. If the health of GBV victims and survivors can be improved (by improving how the healthcare system in their community takes care or treat them, and increasing victims' willingness to report the violent incident) the effect that this variable has on the system of GBV as a whole can be reduced.

The final output of the GBV system was positively influenced by these changes and is presented in Figure 25. Although the graph still illustrates the number of incidents against an individual will steadily increase, a major improvement can be observed in the results. The increase is also not as big as originally that depicted in Figure 24, which shines a positive light on these changes. In the initial poorly managed scenario simulation the number of incidents against an individual over the 100 months was 9.51424. After the sensitivity analysis and related changes, this number was decreased to 1.46067. It should be noted that these values are accurate for how this specific GBV system was designed and set up during modelling. These numbers may differ if changes are made to the system framework and modelling methods.

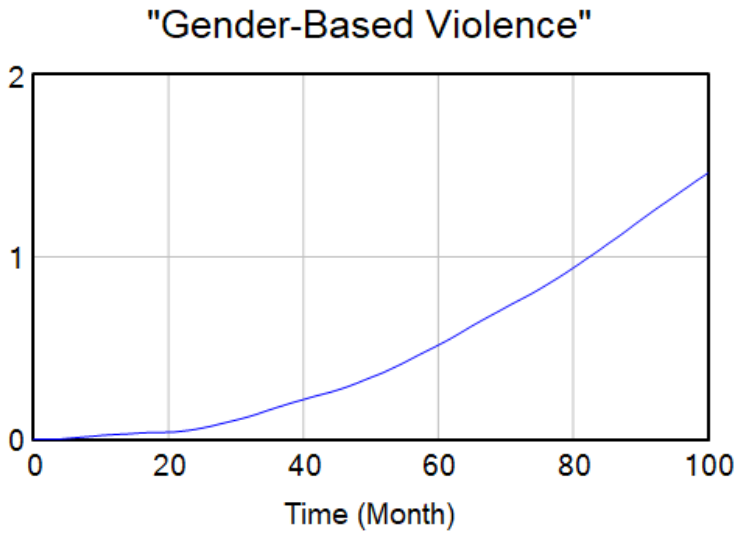

Figure 25 *ty Analysis 1*

A positive overall system change was also observed in the better-managed scenario simulation. The data and equations used in this simulation run are presented in Table 19. The better-managed scenario from 179.427 to 183.40 incidents against an individual over the defined modelling period. From this it is evident that both scenarios produce better results, even though the improvements are minor.

Table 19: Data and equations for the "Better-managed" case scenario during Sensitivity Analysis 1

Variable/driver	***Original equation***	***New equation***
Gender equality	RANDOM.UNIFORM (-0.024482, 0, 0.001)	RANDOM.UNIFORM (-0.030941, 0, 0.001)
Level of education	RANDOM.UNIFORM (-0.024298, 0, 0.001)	RANDOM.UNIFORM (-0.030372, 0, 0.001)
Income generation opportunities	RANDOM.UNIFORM (-0.024298, 0, 0.001)	RANDOM.UNIFORM (-0.030372, 0, 0.001)
Pandemic and lockdown measures	RANDOM.UNIFORM (-0.024298, 0, 0.001)	RANDOM.UNIFORM (-0.030372, 0, 0.001)
Population density	RANDOM.UNIFORM (-0.024221, 0, 0.001)	RANDOM.UNIFORM (-0.030276, 0, 0.001)
Health	RANDOM.UNIFORM (-0.024221, 0, 0.001)	RANDOM.UNIFORM (-0.030276, 0, 0.001)

4.2.6.2. Sensitivity Analysis 2: Changing Selected Groups of Flow Variables

In this part of the sensitivity analysis of the defined GBV system, flow variables were selected and changed in groups for each respective stock variable. Groupings were done by selecting the three flow variables with the highest normalised weighted values per stock variable and running the simulation for each group respectively.

Note that no variables were selected for the Biological factors and Substance Abuse factor stocks, as not enough flow variables serve as input to these stocks. It is also difficult to make changes to the flow variables linked to a person's biological factors, as the only variable where possible intervention attempts can be implemented is the variable "Mental Health Problems". The Substance Abuse stock only has one input flow variable linked to it. These flow variables will therefore be included in the third sensitivity analysis where variables are studied in isolation. The groupings and selected flow variables are shown in Table 20.

Table 20: System variable groupings used during Sensitivity Analysis 2

Stock variable	***Grouping and normalised weight***
Societal factors	Gender equality (normalised weighted value of 0.024482) Income generation opportunities (normalised weighted value of 0.024298) Pandemic and lockdown measures (normalised weighted value of 0.024298)
Personal factors	Level of education (normalised weighted value of 0.024298) Health (normalised weighted value of 0.024221) Opportunities for economic advancement (normalised weighted value of 0.024132)
Economic factors	Income generation opportunities (normalised weighted value of 0.024298) Pandemic and lockdown measures (normalised weighted value of 0.024298) Population density (normalised weighted value of 0.024221)
Religion and Cultural Practices	Gender and social norms (normalised weighted value of 0.024132) Sexual entitlement ideologies (normalised weighted value of 0.024132) Patriarchy (normalised weighted value of 0.024132)

Changes to these different groupings were done similar to the first sensitivity analysis. The values used during the simulation runs were decreased by the same amount to keep results consistent and to compare results later in the report. The sensitivity analysis in this section was performed separately for each grouping, only considering changes in each separate grouping while keeping the rest of the system variables at their original values. The sensitivity analysis was again performed over both simulation scenarios. The data used for the *poorly managed* case scenario is presented in Table 21.

Table 21: Sensitivity Analysis 2 new data and equations for the "Poorly managed" case scenario

Grouping	***Variable/driver***	***Original equation***	***New equation***
1	Gender equality Income generation opportunities Pandemic and lockdown measures	RANDOM.UNIFORM(0.006121, 0.018362, 0.001) RANDOM.UNIFORM(0.006074, 0.018223, 0.001) RANDOM.UNIFORM(0.006074, 0.018223, 0.001)	RANDOM.UNIFORM(0, 0.012242, 0.001) RANDOM.UNIFORM(0, 0.012148, 0.001) RANDOM.UNIFORM(0, 0.012148, 0.001)
2	Level of education Health	RANDOM.UNIFORM(0.006074, 0.018223, 0.001) RANDOM.UNIFORM(0.006055, 0.018166, 0.001)	RANDOM.UNIFORM(0, 0.012148, 0.001) RANDOM.UNIFORM(0, 0.012110, 0.001)

Grouping	*Variable/driver*	*Original equation*	*New equation*
	Opportunities for economic advancement	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)	RANDOM.UNIFORM(0, 0.012066, 0.001)
3	Income generation opportunities	RANDOM.UNIFORM(0.006074, 0.018223, 0.001)	RANDOM.UNIFORM(0, 0.012148, 0.001)
	Pandemic and lockdown measures	RANDOM.UNIFORM(0.006074, 0.018223, 0.001)	RANDOM.UNIFORM(0, 0.012148, 0.001)
	Population density	RANDOM.UNIFORM(0.006055, 0.018166, 0.001)	RANDOM.UNIFORM(0, 0.012110, 0.001)
4	Gender and social norms	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)	RANDOM.UNIFORM(0, 0.012066, 0.001)
	Sexual entitlement ideologies	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)	RANDOM.UNIFORM(0, 0.012066, 0.001)
	Patriarchy	RANDOM.UNIFORM(0.006033, 0.018099, 0.001)	RANDOM.UNIFORM(0, 0.012066, 0.001)

By changing the appropriate system variables in their respective groups, positive system results were achieved for each grouping. The output results of each grouping are discussed below.

New results obtained from Grouping 1:

By changing the three system variables identified in the first grouping, the rate of change that flows into the Societal factors stock (Rate 2) was decreased. This rate change caused the Societal factors stock variable to decrease and showed a big change in not only magnitude but also in direction. The graph on the left depicts the results of the original simulation run. This graph illustrates that if the appropriate intervention measures were to be implemented effectively, the societal factors stock variable for this GBV system will steadily decrease over time.

These changes ultimately have a positive impact on the GBV system as a whole and lead to a reduced number of GBV incidents against an individual over time. Figure 26 shows the improvement that this system undergoes when the necessary changes were made. The number of incidents is reduced from 9.51424 during the initial most probable simulation run to 6.01692.

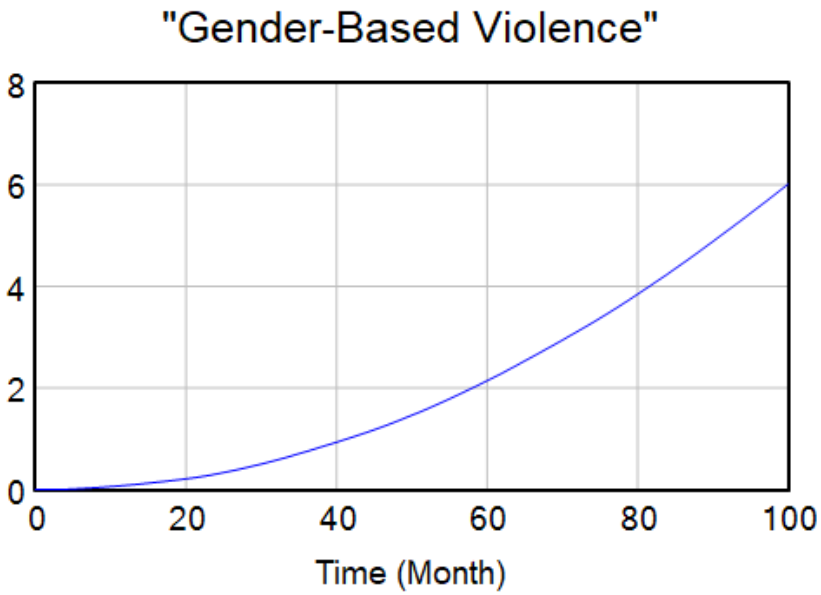

Figure 26: Improvement in system output for Grouping 1

New results obtained from Grouping 2:

The three variables identified as areas where mitigation and intervention attempts can be implemented specifically related to an individual's personal factors have the greatest effect on the Personal factors stock variable in the system. By reducing the values of these variables during simulation, it was possible to decrease the input rate (Rate 3) to the Personal factors stock of this system which also led to a change in the graph of the Personal factors stock variables of this system.

Therefore, by addressing the impact that the three selected flow variables in this grouping has on the system of GBV, the rate of change that flows into the stock variable itself (in this case the Personal factors stock variable) is decreased. These changes ultimately led to an improvement in the system outputs, reducing the number of GBV incidents against an individual over time by 4.28741 of its original value. This is shown in Figure 27, with the final number of incidents at the time equal to 5.22683.

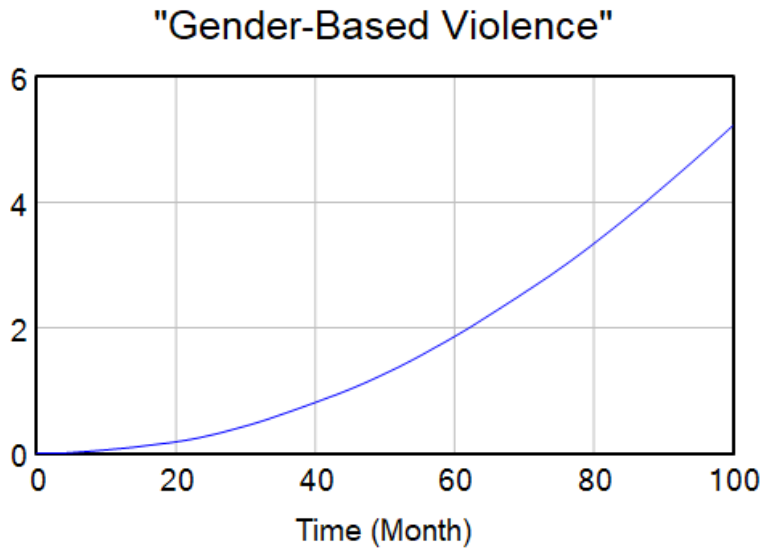

Figure 27: Improvement in system output for Grouping 2

New results for Grouping 3:

A clear decrease in the input rate (Rate 4) to the Economic factors stock variable of this system is observed when the identified system flow variables are decreased. The change observed in the input rate to the stock variable has an impact on the system stock variable itself. A change is observed in the degree or magnitude of impact that this variable has on the system, and not in the direction of impact.

These changes have a positive impact on the overall GBV system, reducing the final output value by 4.12117 incidents from 9.51424 to 5.39307. This positive change is shown in Figure 28.

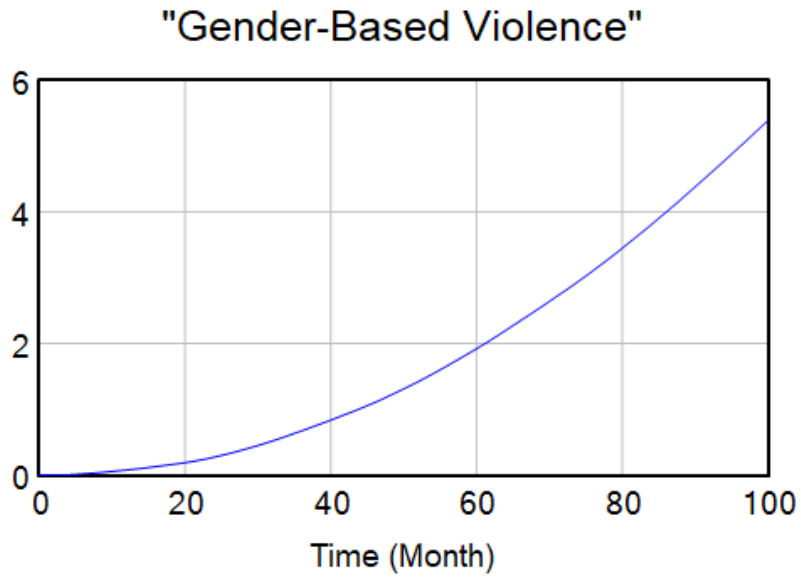

Figure 28: Improvement in system output for Grouping 3

New results from Grouping 4:

Changes made for the final grouping had similar effects on the system as changes to the previous groupings did. The rate of change serves as input to the Religion and Cultural practices stock variable has been reduced by decreasing the values of the identified flow variables during simulation.

The change that this reduction in input rate has on the stock variable itself is minor. A bit more fluctuation is present in the output graph of the stock variable, but the magnitude and direction of impact remain fairly unchanged. These three variables are areas within the system where change can be effectively made with the appropriate intervention strategies and mitigation attempts. By appropriately challenging social and gender norms, legal issues related to this topic can be strengthened and gender stereotypes can be changed for the better.

The violence directed against children and women in different societies and communities is often a direct reflection of their gender stereotypes and norms. This is as individuals in these communities or societies can use these norms as a means of justifying being violent toward other individuals. It is crucial that gender norms are challenged from a young age and should be prevented from an early age. The same reasoning can be applied to sexual entitlement ideologies and patriarchy.

Even though changes to the input rate and stock variable were minor, a positive impact was still observed on the final output of the system. The changes made led to a decrease in the number of GBV incidents against an individual over the defined time period. The number of incidents was reduced from 9.51424 to 6.8347, as shown in Figure 29.

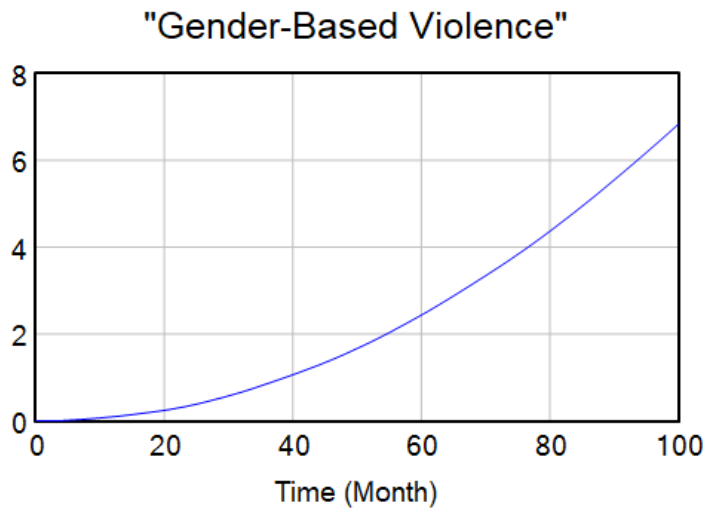

Figure 29: Improvement in system output for Grouping 4

The same process of change was applied to the *better-managed* case scenario simulation runs. The data (after the relevant changes were made) used during the sensitivity analyses of each grouping is presented in Table 22.

Table 22: Data and equations for the "Better-managed" case scenario during Sensitivity Analysis 2

Variable/driver	***Original equation***	***New equation***
Gender equality	RANDOM.UNIFORM (-0.024482, 0, 0.001)	RANDOM.UNIFORM (-0.030941, 0, 0.001)
Income generation opportunities	RANDOM.UNIFORM (-0.024298, 0, 0.001)	RANDOM.UNIFORM (-0.030372, 0, 0.001)
Pandemic and lockdown measures	RANDOM.UNIFORM (-0.024298, 0, 0.001)	RANDOM.UNIFORM (-0.030372, 0, 0.001)
Level of education	RANDOM.UNIFORM (-0.024298, 0, 0.001)	RANDOM.UNIFORM (-0.030372, 0, 0.001)
Health	RANDOM.UNIFORM (-0.024221, 0, 0.001)	RANDOM.UNIFORM (-0.030275, 0, 0.001)
Opportunities for economic advancement	RANDOM.UNIFORM (-0.024132, 0, 0.001)	RANDOM.UNIFORM (-0.030165, 0, 0.001)
Income generation opportunities	RANDOM.UNIFORM (-0.024298, 0, 0.001)	RANDOM.UNIFORM (-0.030372, 0, 0.001)
Pandemic and lockdown measures	RANDOM.UNIFORM (-0.024298, 0, 0.001)	RANDOM.UNIFORM (-0.030372, 0, 0.001)
Population density	RANDOM.UNIFORM (-0.024221, 0, 0.001)	RANDOM.UNIFORM (-0.030275, 0, 0.001)
Gender and social norms	RANDOM.UNIFORM (-0.024132, 0, 0.001)	RANDOM.UNIFORM (-0.030165, 0, 0.001)
Sexual entitlement ideologies	RANDOM.UNIFORM (-0.024132, 0, 0.001)	RANDOM.UNIFORM (-0.030165, 0, 0.001)
Patriarchy	RANDOM.UNIFORM (-0.024132, 0, 0.001)	RANDOM.UNIFORM (-0.030165, 0, 0.001)

Table 23 presents the results obtained from the system after the necessary changes were made. This table shows the final output of the system (thus the number of GBV incidents experienced by an individual over the defined simulation) for the better-managed case scenario. A brief discussion of these results is given in the paragraphs that follow.

Table 23: System output results for the "Better-managed" case scenarios during Sensitivity Analysis 2

Grouping	***Best-case simulation***	***Best-case Improvement (number of incidents)***
1	-181.153	1.726
2	-181.537	2.110
3	-181.385	1.958
4	-181.336	1.909

From this analysis and the results presented in the table above, it is evident that an improvement in the final output result of the system is produced by all groupings in both simulation-run scenarios. Again, this indicates and justifies that any corrective change/improvement to system variables leads to an improved final system output.

4.2.6.3. Sensitivity Analysis 3: Changing System Flow Variables in Isolation

The final sensitivity analysis is performed to determine if changing/addressing system input variables in isolation will have a positive impact on the final results of the system. All the variables identified as good areas for change (in the previous two sensitivity analyses) were used in this scenario.

Again, all variables were tested on both simulation scenarios. The data used for each simulation run are the same as that presented in the previous tables in this section. Two additional system variables are also introduced in this analysis namely, Mental health problems and Normalisation of substance misuse. Data for these two variables are presented in Table 24.

Table 24: Data and equations for Sensitivity Analysis 3

	Original equation		***New equation***	
	Mental health problems	*Normalisation of substance misuse*	*Mental health problems*	*Normalisation of substance misuse*
Poorly managed simulation	RANDOM.UNIFORM (0.005784, 0.017351, 0.001)	RANDOM.UNIFORM (0.005784, 0.017351, 0.001)	RANDOM.UNIFORM (0, 0.011567, 0.001)	RANDOM.UNIFORM (0, 0.011567, 0.001)
Better manged simulation	RANDOM.UNIFORM (-0.023135, 0, 0.001)	RANDOM.UNIFORM (-0.023135, 0, 0.001)	RANDOM.UNIFORM (-0.028919, 0, 0.001)	RANDOM.UNIFORM (-0.028919, 0, 0.001)

Table 25 presents the final output results obtained from this analysis. Due to the number of system variables changed and tested individually, no graphs were included.

Table 25: System output results from Sensitivity Analysis 3

Variable	***Poorly managed simulation***	***Poorly managed simulation improvement***	***Better-manged Simulation***	***Better-managed simulation improvement***
Gender equality	8.88307	0.63117	-179.772	0.345
Level of education	7.81274	1.7015	-180.396	0.969
Income generation opportunities	8.26031	1.25393	-180.031	0.604
Pandemic and lockdown measures	7.90204	1.6122	-180.203	0.776
Population density	8.26529	1.24895	-180.004	0.577

Variable	*Poorly managed simulation*	*Poorly managed simulation improvement*	*Better-manged Simulation*	*Better-managed simulation improvement*
Health	7.90844	1.6058	-180.145	0.718
Opportunities for economic advancement	8.53658	0.97766	-179.850	0.423
Gender and social norms	8.80321	0.71103	-179.791	0.364
Sexual entitlement ideologies	8.80321	0.71103	-179.786	0.359
Patriarchy	7.38115	2.13309	-180.613	1.186
Mental health problems	8.32129	1.19295	-180.008	0.581
Normalisation of substance misuse	4.74244	4.7718	-181.702	2.275

This final sensitivity analysis illustrates that even when only a single variable within the system is addressed and improved, it still has a positive effect on the system and its final output. By running a sensitivity analysis simulation on all the system variables in isolation, and comparing the results with that of the original simulation, a positive overall system effect is observed for all simulation runs.

The improvement noted for the system is presented in Table 25. Even though the improvements are only small in comparison to the improvements seen in the previous two sensitivity analyses, they still illustrate that any positive change to one of these system variables will have a positive effect on the system's output. The system variable that presents the biggest improvement when addressed in isolation is the *Normalisation of substance misuse* variable, whereas the *Gender equality* variable presents the lowest improvement. All of the improvements made by changing the appropriate system variable all lie within a relatively similar range.

From the different sensitivity analyses performed any mitigation or intervention attempt to the system input variables (flow variables) will ultimately improve the final system output. Thus, reducing the impact that this GBV system has on individuals directly or indirectly affected by it. A better system result/output is obtained when more variables are changed or addressed simultaneously. Due to this reason, intervention and mitigation attempts are identified and developed for the system input variables addressed in the first sensitivity analysis.

This change yielded the biggest reduction in GBV incidents over a defined period. If the conditions of the sensitivity analyses were different and if the stock and flow diagram was set up differently, the variables that would be considered using further analysis phases will differ.

In this study, the focus is placed on the results obtained from the different scenarios (ultimately working with the input flow variables that yielded the best results).

4.2.7. Introduction of Control and Mitigation Measures to the defined GBV System

In this section control and mitigation measures are introduced for the system variables that caused the biggest positive system change when decreased, as identified in the sensitivity analysis. These variables were selected and are prioritised for further analysis, based on the combined results of the weight-based modelling and sensitivity analyses performed. The variables considered and discussed in the paragraphs that follow include gender equality, level of education, income generation opportunities, pandemic and lockdown measures, population density and health. It is important to note that the interventions provided in this section are not exhaustive, but may aid in reducing the impact of GBV on individuals and its prevalence rates within communities.

These six system drivers amount to approximately 15 % of the total weight in the GBV system. If these system drivers are effectively addressed the impact of this system on society and individuals can be reduced by this same amount. Therefore, it is crucial to devote enough time and resources on developing and proffering effective and sustainable solution mechanisms for these drivers.

First and foremost, one must consider the issue of funding and resources allocated to the creation and successful implementation of intervention/prevention strategies and initiatives for GBV and its associated problems. Governments need to focus their attention to devoting more of their time to GBV and its prevention and should allocate more of their resources to this problem. Many of the intervention attempts set out by governments fail, either in their implementation or success rates, due to insufficient levels of funding during initiation or maintenance.

For any GBV intervention attempt to be successful, and make a lasting impact in communities and societies, priority must be given to the effective creation and implementation of prevention strategies. These prevention strategies must also be maintained over time and well into the future, so that an overall system change can be observed, and not just a temporary change. Funding also does not have to be solely used for the implementation and maintenance of intervention attempts, but can also be allocated to the institutions that help and support GBV

victims. Providing funding to these organisations enables them to widen the reach that they have within a society or community, and to provide help to a more diversified group of victims.

4.2.7.1. Interventions to Promote Gender Equality

Interventions in this section ultimately aim to empower individuals (especially women and young girls) within a community or society, to strengthen and improve their socioeconomic circumstances and position within society. When developing interventions related to gender equality, one must consider three areas namely gender analysis, raising awareness and creating equal leadership opportunities.

The first area to consider for intervention development in a society or community is to perform a complete gender analysis of that specific community to identify all the genders and different gender barriers that do exist within that community. This will indicate why women do not freely participate in community activities and what specific actions need to be taken to effectively address this problem.

The second area to focus on is creating awareness within the community regarding the problem of GBV. Women are often confined to their situations (for example their households, abusive relationship, lack of financial independence etc.). This hinders their mobility within the community and prevents them from improving their lives and gaining more independence.

The final focus area is to create equal leadership opportunities for women within a community than men. It is too common that women are denied to voice their ideas or concerns. It is argued that if women are placed in leadership roles they improve/transform a certain aspect of a community specifically related to social exclusion, education, health and domestic violence.

Other means of intervention include:

- Raising awareness of different gender identities and developing sensitisation campaigns for young individuals, to reduce gender inequality and ultimately GBV.
- Developing legal literacy campaigns to teach women and girls about their rights and to educate other vulnerable gender groups about the legal avenues that they can use if their human rights have been violated by GBV-related crimes.
- Collaboratively working with police officials and law enforcement to address and combat sexual violence and other forms of GBV (including abuse and harassment) of vulnerable gender groups or populations.

- Reviewing/reforming laws and legal policies related to GBV and violence against women and other minority gender groups. In doing this GBV can be minimised, gender discrimination eliminated and gender equality strengthened.
- Creating a dialogue with traditional and religious leaders in society and regular community members to raise awareness of harmful practices and ideologies/beliefs that violate the human rights and health of children, women and other minority gender groups.
- Creating community leadership programs for young boys and men that enable them to stand up against and challenge harmful social and or gender norms within their community.

Thus, in summary, intervention attempts to promote gender equality in society or community must be able to change harmful beliefs and practices against women and children, challenge discriminatory belief and norms about gender and gender groups, provide additional information to vulnerable individuals about their rights and the steps they can take to seek help or convict perpetrators, introduce further legal actions to prosecute individuals against violent and discriminatory gender crimes or aid in improving communities' knowledge on GBV, gender equality and gender rights.

4.2.7.2. Interventions to Improve Education Equality

All members of a society or community must have the same level of education, and the same amount of opportunities to improve their knowledge and skills. Higher education and proper education are linked to reduced prevalence rates of GBV and its related health problems during later life stages. This is because it promotes education and skills and enables individuals to be more independent and make better life choices. Interventions in this section are twofold as it can be aimed at the improvement of knowledge of all individuals (thus reducing education inequality within a community), or specifically, education initiatives that teach men, boys and other members of the community about concepts such as GBV and its related topics.

Interventions a community can adopt to taking action against gender inequality include:

- Reimagining the public education system, by working with the local government to reinvest or allocate appropriate funding into the local school district (especially into low-income schools). This progressive practice of continuously providing school districts with the funding that they need, can lead to increased and improved opportunities for vulnerable low-income students.

- Creating a fair and non-discriminatory public education system that promotes treating everyone with the necessary consideration, respect and mindfulness.
- Ensuring that the educational justice movement within the community or society is successful. Thus, building the participation, knowledge and leadership skills of those vulnerable individuals who are the most affected by racial, societal and educational injustices.
- Create advocacy programs in collaboration with legal advocacy groups, government officials, individuals within the education sectors and educators themselves that support equity-oriented policy change within the educational/school system of a community.
- Developing support programs that focus on keeping girls in school. In doing so these girls increase their educational knowledge and skills, which allows them to be economically and financially independent during later stages of their lives. It also reduced the likelihood of early or forced marriage, staying in abusive relationships, risky sexual choices or partnerships and ultimately GBV.

Interventions that educate individuals on GBV and its related topics include:

- Developing initiatives that educate community members (especially men and boys) on GBV and the importance of gender equality and human rights.
- Developing community outreach programs, mass media campaigns, mobilisation initiatives and service-based programs for community members on the topic of violence against women and girls and gender rights.
- Creating recruitment programs and engagement strategies that allow men to show a sustained interest and involvement in violence prevention within their communities.
- Initiate and monitor discussion forums and workshops to teach boys about respect and gender equality and allow them to break away from harmful social and gender stereotypes.
- Developing programs that mobilise men and allow them to take action against GBV and support the empowerment of women within their communities.
- Identifying men within a community (and providing them with training and support) to positively influence their male peers and serve as role models to them. In doing this, topics such as promoting gender equality, speaking out about GBV and violence against women and children, equally sharing household responsibilities, etc.

4.2.7.3. Interventions to Increase Income Generation Opportunities

Interventions in this section focus on increasing opportunities for women and disadvantaged gender groups to generate an income. In doing so these individuals become more financially independent and advance easier within a community, society or economy. The financial and economic empowerment of women in a society increases their access to basic economic resources and financial assets. It also provides them with equal job opportunities and skills development.

Various income generation and economic advancement interventions include:

- Ensuring that women, girls and vulnerable gender groups are fully equipped with the necessary knowledge and skills to fully participate in the economy or community.
- Investing in women's companies or organisations (ie. Businesses that are owned by women or who employ mainly female or vulnerable individuals) and supporting their initiatives to increase the number of opportunities for these individuals in the community and reducing various forms of inequalities.
- Recognising unpaid labour as a form of work, to ensure that women do not bear a disproportionate or unfair responsibility for domestic work and unpaid care.
- Enforcing various social protection systems and policies for women within the community and workplace environment.
- Creating new and appropriate roles/positions for women within the work environment. This will allow companies to develop in different ways by using the unique skills and perspectives of women and other vulnerable individuals.
- Diversifying leadership within companies and organisations by promoting women to executive positions and management roles.
- Challenging and changing social laws and policies related to gender differences (for example, ensuring that both men and women/vulnerable gender groups get equal pay for the work that they do).
- Creating decent work for women and vulnerable individuals that ensures their work environment is free from sexual violence and harassment, and promotes a healthy and safe space and ensures equality.
- Creating more flexible options for women in their work environment including consulting, telework or remote working options. This enables women to remain financially stable and ensures their professional continuity, without placing them at a disadvantage when they have family-related obligations.

Companies also play a role and must take action to effectively address GBV and reduce the impact that inequalities in unavailability of income generation opportunities have on individuals within the community. Companies should do this by preventing harassment in the workplace by identifying potential risk indicators, ensuring diversity and gender equality within the workplace and developing policies and procedures that support their employees.

Organisations must go beyond their immediate work environment and collaborate and campaign in different ways as they can influence and change social behaviour and norms related to GBV and its impact. They can do this by using their core business aims and cultural viewpoint and aligning it with advertising or media campaigns. They must also find ways of monitoring GBV within their work environment and taking accountability for it. Data on this can be collected by setting up policies and programs for employees to use as feedback mechanisms to report such behaviour. They can also prioritise resources to address this issue by continuously conducting surveys with their employees.

4.2.7.4. Interventions during Pandemic Situations

Interventions in this section are important as GBV has been one of the outcomes/consequences of pandemic situations that have been most neglected and overlooked, despite its global prevalence. During pandemic situations legal legislature and support services available to GBV victims are scarce and often inadequate or lacking, therefore making the situation worse.

Interventions that can be implemented to assist women and vulnerable gender groups during these times include:

- Firstly, recognising/acknowledging GBV as a complex social issue that has an effect not only on its victims but also on many other individuals within a community or society.
- Recognising the subtle and indirect ways in which victims communicate that they are experiencing or exposed to violence.
- Expanding and increasing the community partnerships and programs that spread awareness on GBV and the importance of speaking out against perpetrators and reporting GBV incidents.
- Working with non-government organisations and gender organisations to provide the necessary support services and assistance to GBV victims.
- Developing telephonic or online services for GBV victims who seek counselling or support services.

- Building on existing or developing new services to appropriately assist GBV victims.
- Strengthening physical or online legal aid services and support initiatives for GBV victims.
- Training healthcare workers and police officials on the tell-tale signs of violence exposure, and how to easily recognise GBV exposure, to effectively tackle the problem.
- Using various media platforms to raise awareness on GBV to effectively support its victims. This can be done in the form of advertisements, social media campaigns or bystander approaches.
- Increase the availability of funding for initiatives and support/protection services to victims.
- Involving authority figures and police officials to effectively assist victims and address the issue of GBV within a community/society.
- Ensuring that women do not get unfairly dismissed or laid off during pandemic situations, forcing them to become economically and financially dependent on their male counterparts.

4.2.7.5. Interventions for Population Density Related Problems

High population densities and population growth are associated to low reduction in poverty levels within a community and may cause many individuals or households to move into poverty or low-income situations. Communities must work with their local governments or municipalities to develop intervention strategies or programs that aid in reducing the impact of high population densities on the individuals within their communities. Some interventions include:

- Ensure that there are enough employment opportunities within a community or society to accommodate the number of individuals who live in that specific area. This can be in the form of informal or informal paid work, that ensures individuals obtain some form of income.
- Develop policies related to the use and consumption of natural resources, to ensure that important resources are not unnecessarily exploited and that all individuals in the community have equal access to these resources.
- Develop strategies that allow the population density of a community to be used for the benefit of economic growth and development of that community and the individuals who live there.

- Develop strategies to reduce poverty and the number of unemployed poor households in a community, by providing them with the necessary social support and employment opportunities.
- Develop and enforce policies or laws that allow individuals to improve their quality of life by gaining the appropriate economic exposure, opportunities and resources.
- Work with local law enforcement and police officials to reduce the rate of crime in communities caused by high population densities and the lack of basic resources.
- Create and enforce environmental policies to ensure that the living and natural environment within a community does not degrade, become dangerous or unhealthy for its members due to high population densities.
- Ensure that the per capita income (i.e. The amount of money that each person within a geographic area earns) is more or less equally distributed/similar for the lower-class individuals within a community.

4.2.7.6. Interventions for Health and Healthcare

Healthcare plays an important role in GBV prevention and support and ensures that the health of GBV victims is effectively addressed. Healthcare in this field is however often lacking as healthcare workers do not know how to effectively identify, deal with or care for GBV victims. Victims themselves are also reluctant to report GBV directed against them due to the stigma that may be associated with them when they do.

The impact of GBV can be improved and its prevalence minimised by the following interventions in the healthcare sector:

- Establishing primary means of GBV prevention by promoting community awareness and knowledge in this field.
- Emphasising and focusing on early identification of GBV or GBV-related crimes.
- Ensuring confidentiality is maintained when working with GBV victims or survivors, treating them with the necessary care and respect, and monitoring their health and health improvements.
- Providing GBV victims treatment or support at a physical and mental health level.
- Developing programs for GBV victims and survivors that provide them with long-term GBV counselling and rehabilitation.
- Referring victims to various social, legal and economic support systems.

- Improving the interactions between patients (i.e. GBV victims and survivors) and healthcare providers to effectively address GBV and its impact.
- Educate and train healthcare workers on the practices, attitudes and effects of GBV on its victims and the general community.
- Develop, implement and continuously monitor GBV policies and guidelines within the healthcare system to ensure that treatment and care options remain up to date and effective.
- Improving how healthcare workers document and keep a record of GBV cases and treatment.
- Strengthening partnerships with gender organisations and social services to provide GBV victims with a means of child protection, community support, shelter and safety.

4.2.8. GBV Barometer Application

In this final section of analysis for the defined GBV system, a barometer was deployed utilising an interactive dashboard of system Key Performance Indicators (KPIs). All systems have various metrics and KPIs that need to be tracked, regardless of the system's size or complexity. Without effectively measuring and tracking this data in a system, the decision-maker must often rely on their intuition and guesswork.

For this study, the barometer was created in Microsoft Excel and is used to measure the impact of the selected KPIs on the GBV system. The functionality of the dashboard was premised on the computational outputs obtained from the HSIM prioritisation model. This barometer was used to determine the GBV risk level to which two individuals (a possible victim and possible perpetrator) is exposed during their interaction(s) or in their relationship. The KPIs selected for this dashboard are the six system drivers found to have the biggest effect and impact on the GBV system as a whole, from the sensitivity analyses performed.

A dashboard that graphically displays KPIs and system metrics enables organisations, management and interested parties to analyse the performance of a system efficiently. These dashboards also provide management with a tool and potential platform to monitor the system and allow them to gain additional insight for decision making.

Figure 30 depicts the interactive dashboard in an untested view. With this untested view of the interactive dashboard it is possible to use it as an automated way of performing diagnostic and

evaluation tests to determine the GBV perpetrating tendencies between two interacting individuals. Each system driver presented in the dashboard can embody a value between 0%-100%, depending on the scenario being tested. This range of values was divided into different categories of likelihood (i.e. the likelihood that an individual is affected by this KPI). The different categories include:

- Low likelihood: values ranging between 0%-25% (numerically written as $0\% \leq x \leq 25\%$)
- Moderate likelihood: values ranging between 25%-50% (numerically written as $25\% \leq x \leq 50\%$)
- Medium likelihood: values ranging between 50%-75% (numerically written as $50\% \leq x \leq 75\%$)
- High likelihood: values ranging between 75%-100% (numerically written as $75\% \leq x \leq 100\%$)

In the dashboard, the intensity of importance rating of the KPIs (i.e. How much weight each system driver carries in the GBV system) and the scale rating (i.e. How much that driver impacts the livelihood of an individual) can be changed. These values can be changed to depict different interactions between two individuals, of which one is a possible victim and the other is a possible perpetrator. From this, it is possible to determine and visually depict the overall effect of the various KPIs on the system (taking into consideration both individuals) utilising the output of the dashboard. This dashboard also depicts the risk of GBV occurring when two individuals interact in a certain way.

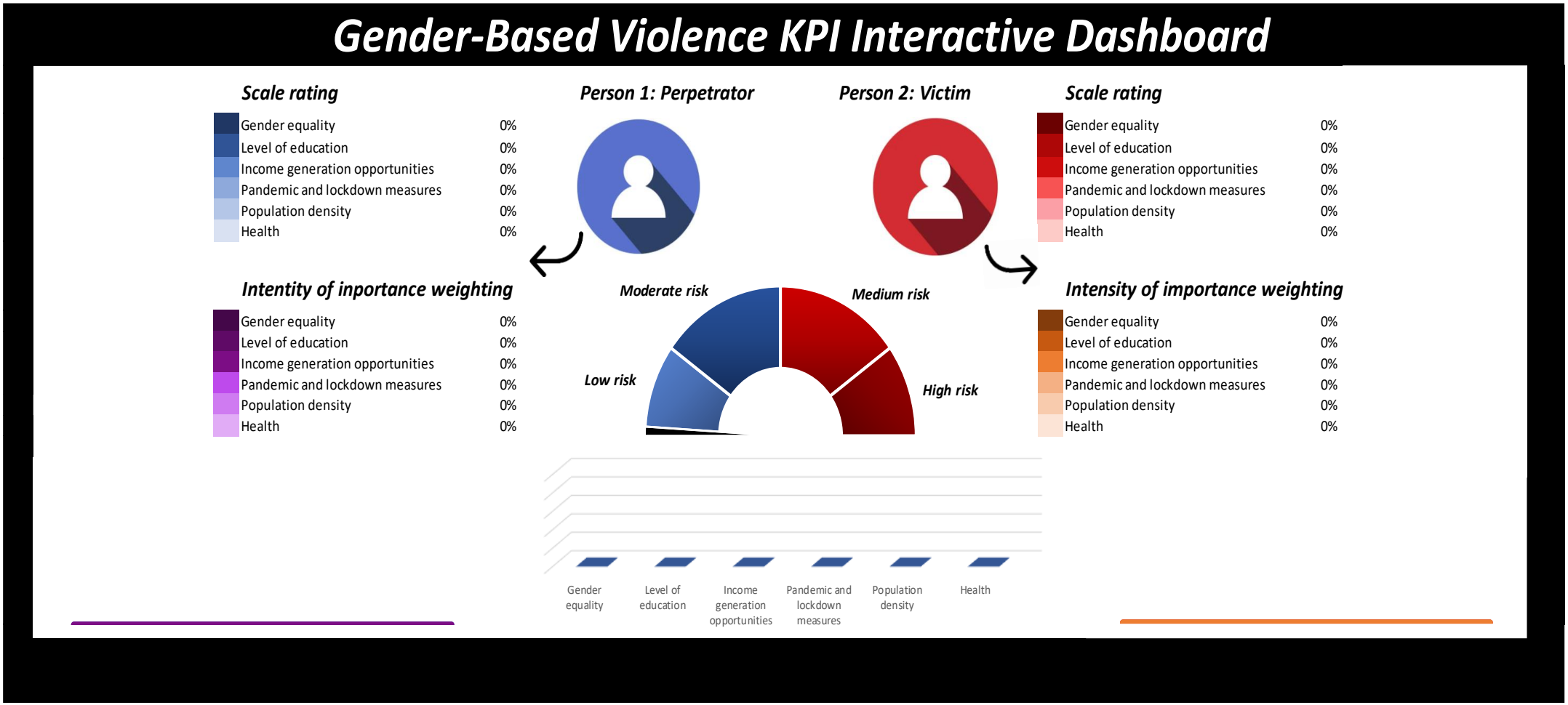

Figure 30: Untested KPI Interactive Dashboard for the GBV System

In Figure 30, no graphs or output is evident, as all values are set to 0%. To change this output various experiments can be performed on this dashboard. Three experiments were performed to evaluate and test the GBV perpetrating tendencies between two interacting individuals and the GBV risk level between them. Table 26 provides a summary of the different experiments performed and the range of values that was encompassed by each individual.

Table 26: Experiment data for KPI Interactive Dashboard Evaluation

Experiment no	***Individual type***	***KPI Scale rating value range***	***KPI Intensity of Importance rating value range***
Experiment 1	Victim	Low likelihood	Moderate likelihood
	Perpetrator	Medium likelihood	Moderate likelihood
Experiment 2	Victim	Moderate likelihood	Medium likelihood
	Perpetrator	Medium likelihood	Low likelihood
Experiment 3	Victim	High likelihood	Medium likelihood
	Perpetrator	Moderate likelihood	High likelihood

Figure 31 to Figure 33 illustrates the results of the different experiments respectfully. These experiments illustrate that the higher the selected values for the scale rating and intensity of importance rating for both individuals, the higher the risk of GBV between these individuals. As the goal would ultimately be to reduce and keep the risk level to a minimum the risk level should preferably fall within the low or moderate risk levels. The paragraphs that follow provide a high-level summary of the results obtained from each experiment.

The output from experiment one indicates that *Moderate risk* level of GBV occurrence between two individuals. A 2% change exists that Gender Equality will impact the interaction(s) between two individuals. Similarly, a 3% change that the Level of Education of these individuals will affect their interaction(s). Income Generation Opportunities, Pandemic and Lockdown Measures, Population Density and Health all show a 1% chance of impacting the behaviour and interaction(s) between two individuals.

The second experiment's outcome also indicates a *Moderate risk* level of GBV occurring between two interacting individuals. A 2% change exists that Income Generation Opportunities and Pandemic and Lockdown Measures will have an impact on the interaction(s) of these two individuals. A 3% change exists for both Population Density and Health to have an effect on the interaction(s) that take place between these individuals. Finally, the Level of Education and Gender Equality pose a 5% and 1% respectively.

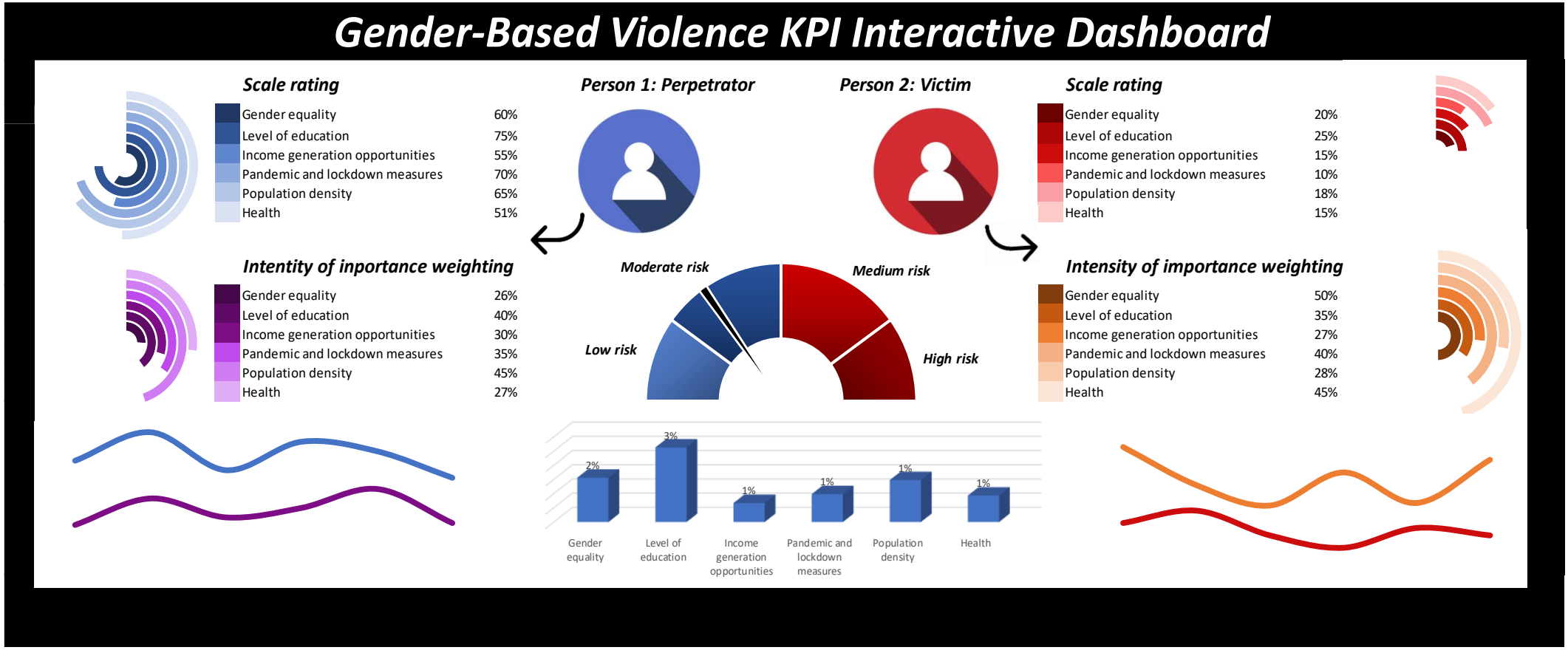

Figure 31: GBV KPI Interactive Dashboard Evaluation - Experiment 1

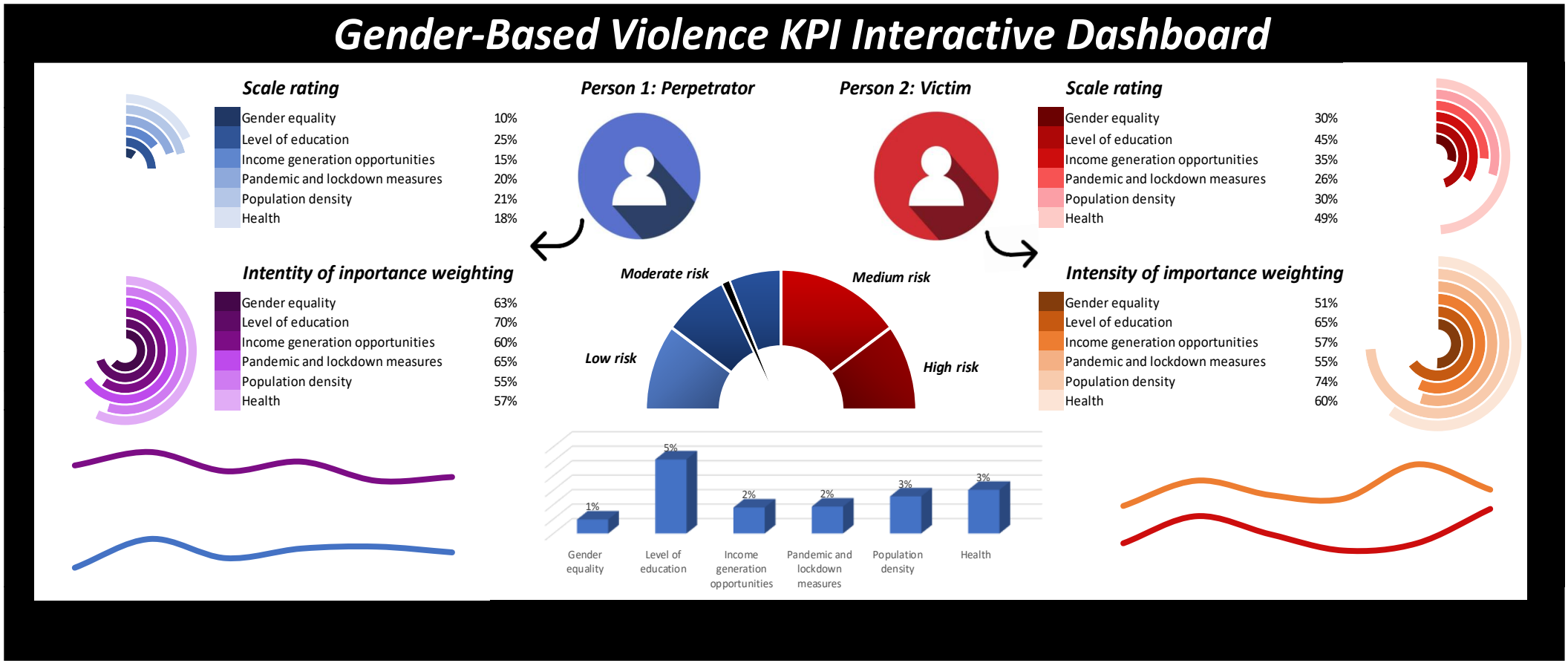

Figure 32: GBV KPI Interactive Dashboard Evaluation - Experiment 2

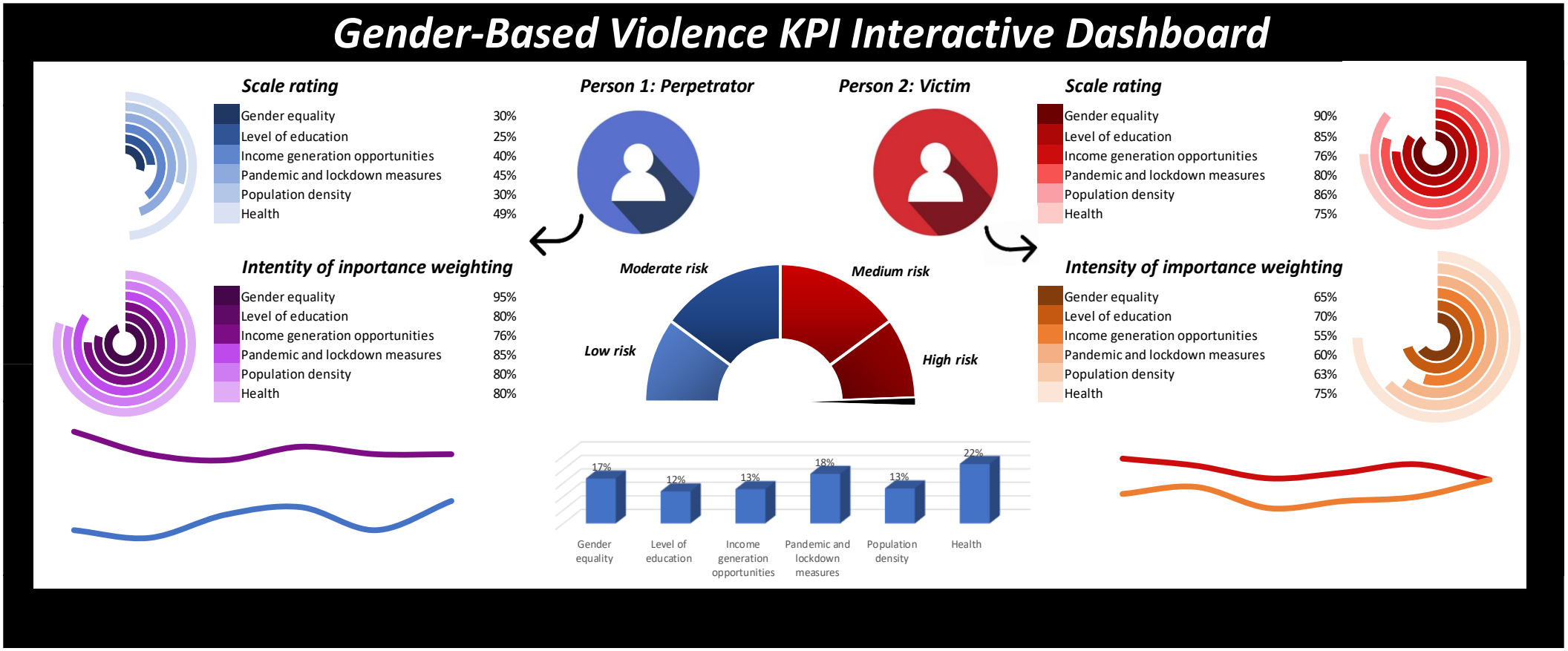

Figure 33: GBV KPI Interactive Dashboard Evaluation - Experiment 3

The final experiment indicated that a *High-risk* level exists for GBV to take place between two individuals that interact in this defined manner. A 17% change exist that *Gender Equality* will impact the interaction(s) between two individuals. A 12% change exists in the *Level of Education* that the two individuals have will impact their interaction(s). The Income Generation Opportunities of these individuals and the Population Density where they reside both have a 13% chance of impacting the interaction(s) between them. Finally, Pandemic and Lockdown Measures and Health pose an 18% and 22% change of impacting the behaviour and interaction(s) between the two individuals respectfully.

From these experiments, it is concluded that the combination of low, moderate and medium likelihood levels (for both the scale and intensity of importance rating for both individuals) had a smaller effect on the system output. As soon as a high likelihood value range was introduced to the interactions between two individuals, the effect on the system was severe. Through these experiments, the interactive dashboard and its output were validated as the results are more or less what would be expected for each interaction. The various experiments indicate that the interactive dashboard developed for the GBV system is indeed capable of serving as a measurement barometer and aiding in estimating the risk of GBV occurrence between two individuals.

Chapter 5
Conclusion and Recommendations

5.1. Overview

This dissertation has presented Gender-Based Violence (GBV) as a complex social engineering problem and emphasises why there is a need for a holistic engineering-based solution to address this. The research aimed to develop an integrated and holistic engineering-based solution premised on systems thinking to address GBV as a complex social problem. This research also aimed to supplement the existing literature on GBV problem solving environment.

In this research, GBV was effectively and successfully modelled, eliminating the bias that individuals introduce to the system, by using a secondary means of data collection. Chapter 1 of this report introduced the concept of GBV and emphasised why it can be defined as a complex social problem. The need for an engineering-based solution approach to address GBV and its related problems was highlighted. Appropriate research questions and their related research objectives have been properly defined to address the problem identified. The limitations and delimitations of the research have been clearly stated.

An in-depth literature study was conducted in Chapter 2 of this research describing the concept of GBV, its causes and related risk factors and current prevention/intervention attempts. Systems thinking (ST) was discussed and appropriate modelling approaches, tools and techniques in this focus area were identified. System dynamics (SD) was defined and its related tools, techniques and modelling approaches mere discussed. Literature was also provided on previous case studies where SD was used to address and model social problems. Finally, literature was conducted in the prioritisation and decision science methodology focus area and on barometer development techniques.

The alternative and preferred solutions for this research were stated in the final sections of Chapter 2. Various techniques, tools and approaches were identified for each defined research objective based on the literature review. The different alternatives were compared against each

other (using appropriate criteria specifically developed for each objective). The alternatives that were found to be best in addressing each research objective was selected and used as the preferred solution(s) to this problem.

A brief review was given on different methodologies that would be appropriate for this research. After comparison, a case study research was selected. The case considered in this study is the GBV system. Tight system boundaries were used for this case. The conceptual framework (visually illustrating the approach to be followed) and a theoretical framework (giving more information on the theories behind the selected tools and techniques) were developed and used as input in Chapter 4.

The data used to model this system was presented analysed and the results thereof were discussed in Chapter 4. The data presented is both qualitative and quantitative and a more secondary means of data collection was utilised. The qualitative data was secondary from archived sources while the quantitative data was algorithmically generated through the prioritisation model deployed in this research. An Ishikawa diagram was used to identify various primary and secondary system drivers. The interactions and "cause and effect" relationship between the system drivers were identified and depicted in a causal loop diagram (CLD). Prioritisation of these system drivers (based on the interactions identified in the CLD) was done using the Hybrid Structural Interaction Matrix (HSIM) technique. A hierarchy of system drivers was created and a normalised weighting for each system driver was calculated. The GBV systems' complexity was quantified and the impact thereof on society at large was illustrated in a spider diagram.

A Stock and Flow diagram was developed for the GBV system. This diagram was used to understand the behaviour of the GBV system and the interactive dynamics that exist between different system drivers that interact. Various simulation runs (in the form of poorly managed and better-managed scenarios) were performed using this diagram. This diagram was also used for Sensitivity Analyses of the system. The values of the different system drivers were manually changed during analysis to identify which variables have the greatest impact on the system. These variables formed the Key Performance Indicators (KIPs) of the system. Different intervention attempts and prevention strategies were identified and developed for each KPI. Finally, a GBV KPI Interactive Dashboard was deployed to serve as measurement Barometer capable of assessing and estimating the risk of GBV occurrence between any two interacting individuals of the opposite gender.

5.2. Findings

Through this research, it was found that there currently is no suitable engineering-based solution(s) available to address the social problem of GBV. It was determined that many factors play a role and impact this system and that the interactions that exist within the system make it complex. Six system drivers namely, gender equality, level of education, income generation opportunities, pandemic and lockdown measures, population density and health were identified as KPIs of this system. This was deduced from the Sensitivity Analyses performed. This grouping of variables had the biggest positive impact on the overall system when addressed. Through the analysis, it can be concluded that any positive change to a system variable will have a positive overall impact on the system, even though it is minor. Changing this grouping of KPIs does however have the biggest positive impact. It can therefore be recommended that more attention and resources be devoted by governments and gender organisations to effectively address the problem of GBV. This research also indicated that engineering-based tools, techniques and methods can be used to address and effectively model social systems like that of GBV.

5.2.1. High-level summary of findings

This subsection provides a brief high-level summary of the results obtained from the data analysis performed. This summary provides key information about the most important results and outcomes of the research.

GBV System drivers

- Total number of system drivers identified = 42 drivers
- Primary system drivers = 6
- Secondary system drivers = 36

Normalised weighted value determined for each system driver for prioritisation purposes

- The normalised weighted values developed during the analysis phases of this research is presented in Table 14.

System complexity quantified

- Baseline GBV System complexity = 100%
- Degree of complexity for the GBV System (when 10 variables are addressed in conjunction) = ± 95%
- Improvement noted = 5%

GBV System Dynamics Modelling

The magnitude and direction (i.e. if the value is positive or negative) of the values presented in this section is more of a symbolic representation of the GBV system's behaviour rather than indicators of real-life events or actual numbers.

Better-managed scenario

- Initial system output = - 179.427
- Improved system output after Sensitivity Analysis = - 183.40
- Improvement = System output reduced by 3.973

Poorly managed scenario

- Initial system output = + 9.51424
- Improved system output after Sensitivity Analysis = + 1.46067
- Improvement = System output reduced by 8.05357

Interventions to address System KPIs

- Approximately 70 interventions were developed for six system KPIs

5.3. Research Objectives addressed

At the end of the research, the defined research questions were effectively addressed. Below is a summary of how each research objective was addressed.

- ***Research objective 1***: This objective was achieved by firstly identifying various GBV system drivers using an Ishikawa diagram (as seen in Section 4.2 page 65) and secondly creating an integrated network of these system drivers and showing the interactions that exist among the system variables utilising a CLD (seen in Section 4.2.1 page 74).
- ***Research objective 2***: This objective was met by prioritising the identified system drivers in a hierarchy, developing and assigning weights to each system driver in this hierarchy of factors utilising the HSIM technique (seen in Section 4.2.2 and Section 4.2.3 on pages 72-81).
- ***Research objective 3***: This research objective was achieved by firstly utilising a Spider diagrams to illustrate system complexity and the effect that this system has on society at large (as shown in Section 4.2.4 on pages 81-87). Secondly, by creating a Stock and Flow diagram as shown in Section 4.2.5 to perform simulation runs for different scenarios obtaining initial system values (this is seen on pages 90-96). Finally performing various Sensitivity Analyses on the different scenarios to determine what

the effect was on the total system (as presented in Section 4.2.6 pages 96-110). In doing this system KPIs were identified and intervention strategies for each developed and formulated for proper management guidance toward solution development and provision (presented in Section 4.2.7 pagse 110-118).

- ***Research objective 4***: This objective was met by deploying a KPI Interactive Dashboard to serve as measurement Barometer for the GBV system (shown in Section 4.2.8 pages 118-125).

5.4. Future work

The work presented in this research is pioneering the quantitative aspect of data and modelling for GBV systems. As the engineering-based literature in this problem space is limited and scanty in terms of quantitative information available, there are various opportunities for future work to come from this research namely:

- Sourcing real-world data on various qualitatively driven system factors.
- Adding additional system drivers and variables to the current dashboard and automating the current dashboard.
- Creating a digital version of this dashboard to get real-time system output.
- Developing control and mitigation strategies for additional system drivers.
- Determine where the turning point lies for the GBV system's behaviour (i.e. where the graph(s) of the simulation output changes from increasing to decreasing).

An opportunity also exists for this research to be used by the United Nations Women Organisation to enable them to reach Strategic Development Goal number 5 (SDG 5) of their Sustainable Development plan effectively. This development goal aims to end all forms of violence, harmful practices and discrimination against women and girls globally. Ultimately, the organisation hopes to achieve gender equality for women and girls in all private and public spheres. This development goal also encourages equal work and leadership opportunities for and full participation of young girls and women in economic and political decision-making.

This research enhances the use of technology (in the form of an interactive dashboard) enabling the organisation to promote and empower women and girls. It will also allow the organisation to develop and adopt sound and enforceable policies and strengthen legislation that promotes gender equality at all economic and societal levels.

Bibliography

ANDERSON, V. & JOHNSON, L. 1997. *Systems Thinking Basics*, Pegasus Communications Cambridge, MA.

ATTRI, R., DEV, N. & SHARMA, V. 2013. Interpretive structural modelling (ISM) approach: an overview. *Research Journal of Management Sciences,* 2(2)**,** 3-8.

AYOMOH, M. & OKE, S. 2006. A framework for measuring safety level for production environments. *Safety Science,* 44**,** 221-239.

AYOMOH, M., OKE, S., ADEDEJI, W. & CHARLES-OWABA, O. 2008. An approach to tackling the environmental and health impacts of municipal solid waste disposal in developing countries. *Journal of Environmental Management,* 88**,** 108-114.

BALANCED SCORECARD INSTITUTE. 2022. *How to Create a Balances Scorecard: Nine Steps to Success* [Online]. Available: https://balancedscorecard.org/about/nine-steps/ [Accessed].

BARILLAS, U. 2017. *Six Characteristics of Highly Effective Data Dashboards* [Online]. Available: https://stratafolio.com/six-characteristics-highly-effective-data-dashboards/ [Accessed 24 November 2021].

CAVANA, R. Y. & MAANI, K. E. A Methodological Framework for Systems Thinking and Modelling (ST&M) Interventions. ICSTM, 2000.

COLLINS, A., LOOTS, L., MEYIWA, T. & MISTREY, D. 2009. Nobody's business: Proposals for reducing gender-based violence at a South African university. *Agenda,* 23**,** 33-41.

CRAVIT, R. 2021. *What is a Decision Tree and How to Make One [Templates + Examples]* [Online]. Available: https://venngage.com/blog/what-is-a-decision-tree/ [Accessed 3 November 2021].

DECKER, M. R., LATIMORE, A. D., YASUTAKE, S., HAVILAND, M., AHMED, S., BLUM, R. W., SONENSTEIN, F. & ASTONE, N. M. 2015. Gender-based violence against adolescent and young adult women in low-and middle-income countries. *Journal of Adolescent Health,* 56**,** 188-196.

DELVE. 2021. *Practical Guide to Grounded Theory Research* [Online]. Available: https://delvetool.com/groundedtheory [Accessed 15 November 2021].

DLAMINI, N. J. 2021. Gender-based violence, twin pandemic to COVID-19. *Critical Sociology,* 47**,** 583-590.

DUTTON, D. 1994. Patriarchy and Wife Assault: The Ecological Fallacy. *Violence and victims,* 9**,** 167-82.

ENAIFOGHE, A., DLELANA, M., ABOSEDE, D. A. & DLAMINI, N. P. 2021. The Prevalence of Gender-Based Violence against Women in South Africa: A Call for Action. *African Journal of Gender, Society and Development,* 10**,** 117-146.

FINCHILESCU, G. & DUGARD, J. 2018. Experiences of Gender-Based Violence at a South African University: Prevalence and Effect on Rape Myth Acceptance. *Journal of Interpersonal Violence,* 36**,** 088626051876935.

FORRESTER, J. W. 1971. Counterintuitive behavior of social systems. *Theory and Decision,* 2**,** 109-140.

FORRESTER, J. W. 1994. System dynamics, systems thinking, and soft OR. *System Dynamics Review,* 10**,** 245-256.

FUCHS, H. U. 2006. System dynamics modeling in science and engineering. *Centro de investigación para la ciencia e ingeniería, Mayaguez: Sistemas dinámicos en la Universidad de Puerto Rico*.

GARCÍA-MORENO, C., JANSEN, H., ELLSBERG, M., HEISE, L. & WATTS, C. 2005. WHO Multi Country Study on Women's Health and Domestic Violence Against Women. *Book WHO Multi-country Study on Women's Health and Domestic Violence against Women,* 204.

GBV SUB SECTOR WORKING GROUP - NIGERIA 2017. Strategy for Gender Based Violence Prevention, Mitigation and Response in the Humanitarian Context.

GOULDING, C. 2002. *Grounded theory: A practical guide for management, business and market researchers*, Sage.

HAIG, B. D. 2010. Abductive Research Methods. *In:* PETERSON, P., BAKER, E. & MCGAW, B. (eds.) *International Encyclopedia of Education (Third Edition).* Oxford: Elsevier.

HAYWARD, E. 2021. The Starter Guide to Dashboards. Available from: https://www.klipfolio.com/blog/starter-guide-to-dashboards.

HOMER-DIXON, T. 2011. Complexity science. *Oxford Leadership Journal,* 2**,** 1-15.

HOMER, J. B. & HIRSCH, G. B. 2006. System dynamics modeling for public health: background and opportunities. *American journal of public health,* 96**,** 452-458.

HOVMAND, P. S. & FORD, D. N. 2009. Sequence and timing of three community interventions to domestic violence. *American journal of community psychology,* 44**,** 261.

HOVMAND, P. S., FORD, D. N., FLOM, I. & KYRIAKAKIS, S. 2009. Victims arrested for domestic violence: unintended consequences of arrest policies. *System Dynamics Review: The Journal of the System Dynamics Society,* 25**,** 161-181.

INTERIM STEERING COMMITTEE 2020. NATIONAL STRATEGIC PLAN ON GENDER-BASED VIOLENCE & FEMICIDE HUMAN DIGNITY AND HEALING, SAFETY, FREEDOM & EQUALITY IN OUR LIFETIME.

JACKSON, M. C. 2006. Creative holism: a critical systems approach to complex problem situations. *Systems Research and Behavioral Science,* 23**,** 647-657.

KIM, D. 2021. *PALETTE OF SYSTEMS THINKING TOOLS* [Online]. Available: https://thesystemsthinker.com/palette-of-systems-thinking-tools/ [Accessed 10 October 2021].

KPMG 2022. Too costly to ignore – the economic impact of gender-based violence in South Africa.

KRUG, E. G., MERCY, J. A., DAHLBERG, L. L. & ZWI, A. B. 2002. The world report on violence and health. *The Lancet*, 360**,** 1083-1088.

KUNC, M. System dynamics: a soft and hard approach to modelling. 2017 Winter Simulation Conference (WSC), 2017. IEEE, 3-6 December 2017, Las Vagas, NV, USA, 597-606.

LUCAS, C. 2000. Quantifying complexity theory. *CALResCo Group. URL: http://www. calresco. org/lucas/quantify. htm*.

MACKEY, A. & BRYFONSKI, L. 2018. Mixed methodology. *The Palgrave Handbook of Applied Linguistics Research Methodology*. Springer.

MAROELA MEDIA. 2021. *Polisie "onbevoeg" met misdaad in sy midde* [Online]. Available: https://maroelamedia.co.za/nuus/sa-nuus/polisie-onbevoeg-met-misdaad-in-sy-midde/ [Accessed 20 September 2021].

MARYANI, A., WIGNJOSOEBROTO, S. & PARTIWI, S. G. 2015. A system dynamics approach for modeling construction accidents. *Procedia Manufacturing*, 4**,** 392-401.

MASEKA, M. 2021. *Experts discuss femicide in SA during UP-hosted webinar* [Online]. Available: https://www.up.ac.za/news/post_3027384-experts-discuss-femicide-in-sa-during-up-hosted-webinar [Accessed 23 October 2021].

MILE, K. 2020. *Gender Based Violence: A South African Plague*.

MILES, A. 2009. Complexity in medicine and healthcare: people and systems, theory and practice. *Journal of Evaluation in Clinical Practice*, 15**,** 409-410.

MIND TOOLS. 2021. *Decision Trees Choosing by Projecting "Expected Outcomes"* [Online]. Available: https://www.mindtools.com/dectree.html [Accessed 4 November 2021].

NAUMANN, R. B., AUSTIN, A. E., SHEBLE, L. & LICH, K. H. 2019. System dynamics applications to injury and violence prevention: a systematic review. *Current Epidemiology Reports*, 6**,** 248-262.

NAYAK, M., BYRNE, C., MARTIN, M. & ABRAHAM, A. 2003. Attitudes Toward Violence Against Women: A Cross-Nation Study. *Sex Roles*, 49.

POLI, R. 2013. A note on the difference between complicated and complex social systems. *Cadmus*.

RAHMAN, M., HOQUE, M. & MAKINODA, S. 2011. Intimate Partner Violence Against Women: Is Women Empowerment a Reducing Factor? A Study from a National Bangladeshi Sample. *Journal of Family Violence*, 26**,** 411-420.

RAMANATHAN, R. 2004. Multicriteria Analysis of Energy. *In:* CLEVELAND, C. J. (ed.) *Encyclopedia of Energy*. New York: Elsevier.

RAMSEY, M. 2016. Six ways to end gender-based violence. Available from: https://degrees.fhi360.org/2016/12/six-ways-to-end-gender-based-violence/.

RODRIGUEZ-ULLOA, R. & PAUCAR-CACERES, A. 2005. Soft system dynamics methodology (SSDM): combining soft systems methodology (SSM) and system dynamics (SD). *Systemic Practice and Action Research*, 18**,** 303-334.

ROSS, T. J. 2005. *Fuzzy logic with engineering applications*, John Wiley & Sons.

ROY, R. Bulk Delays in System Dynamics Model. Proceedings of the 18th International Conference of the System Dynamics Society, Bergen, Norway. System Dynamics Society: Albany, NY, 2000. Citeseer.

RUSSO, N. F. & PIRLOTT, A. 2006. Gender-Based Violence Concepts, Methods, and Findings. *Annals of the New York Academy of Sciences*, 1087**,** 178-205.

SAFERSPACES. 2022. *Gender-Based Violence at Higher Education Institutions in South Africa* [Online]. Available: https://www.saferspaces.org.za/understand/entry/gender-based-violence-at-higher-education-institutions-in-south-africa1 [Accessed].

SERRAT, O. 2017. Understanding complexity. *Knowledge Solutions*. Springer.

STATS SA 2021. Crimes against women in South Africa, an analysis of the phenomenon of GBV and femicide.

STERMAN, J. 2000. Business Dynamics, System Thinking and Modeling for a Complex World. *http://lst-iiep.iiep-unesco.org/cgi-bin/wwwi32.exe/[in=epidoc1.in]/?t2000=013598/(100)*, 19.

STERMAN, J. 2002. System Dynamics: systems thinking and modeling for a complex world.

STERMAN, J. D. 2001. System dynamics modeling: tools for learning in a complex world. *California management review*, 43**,** 8-25.

TELLIS, W. 1997. Application of a case study methodology. *The qualitative report*, 3**,** 1-19.

THE CENTRE FOR THE STUDY OF VIOLENCE AND RECONCILLIATION 2016. Gender-Based Violence (GBV) in South Africa: A Brief Review.

TOOLSHERO. 2021. *Multiple Criteria Decision Analysis (MCDA)* [Online]. Available: https://www.toolshero.com/decision-making/multiple-criteria-decision-analysis-mcda/ [Accessed 3 November 2021].

UN WOMEN. 2016. *The economic costs of violence against women* [Online]. Available: https://www.unwomen.org/en/news/stories/2016/9/speech-by-lakshmi-puri-on-economic-costs-of-violence-against-women [Accessed 15 June 2022].

UN WOMEN. 2020. *Take action: 10 ways you can help end violence against women, even during a pandemic* [Online]. Medium.com/@UN_Women. Available: https://www.unwomen.org/en/news/stories/2020/11/compilation-take-action-to-help-end-violence-against-women [Accessed 25 September 2021].

UN WOMEN. 2022. *SDG 5: Achieve gender equality and empower all women and girls* [Online]. Available: https://www.unwomen.org/en/news/in-focus/women-and-the-sdgs/sdg-5-gender-equality [Accessed].

VARGAS, R. V. 2010. Using the analytic hierarchy process (ahp) to select and prioritize projects in a portfolio. *PMI® Global Congress 2010*. North America, Washington, DC: Project Management Institute.

VIVIER, T. L. 2021. *Anger Management Crucial in Solving Increase of GBV in South Africa* [Online]. Available: https://www.goodthingsguy.com/opinion/anger-management-solves-gbv-sa/ [Accessed 27 September 2021].

WISDOM, J. & CRESWELL, J. W. 2013. Mixed methods: integrating quantitative and qualitative data collection and analysis while studying patient-centered medical home models. *Rockville: Agency for Healthcare Research and Quality*.

WORLD HEALTH ORGANIZATION 2010. Violence prevention: the evidence.

WORLD HEALTH ORGANIZATION 2013. *Responding to intimate partner violence and sexual violence against women: WHO clinical and policy guidelines*, World Health Organization.

WORLD HEALTH ORGANIZATION. 2020. *Violence against children* [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/violence-against-children [Accessed 16 September 2021].

WORLD HEALTH ORGANIZATION. 2021. *Violence against women* [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/violence-against-women [Accessed 16 September 2021].

Appendix A

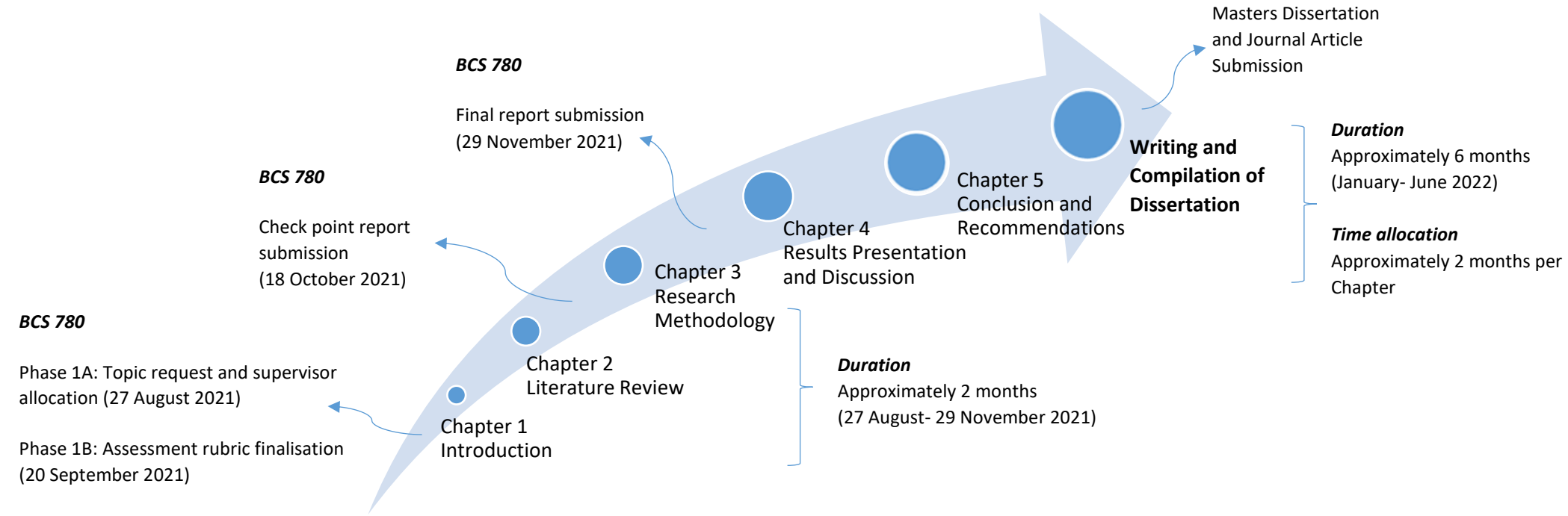

Figure 34: Master's degree timeline

Appendix B

The code below was extracted from the original “Poorly managed” case scenario simulation run. A similar code is observed in the “Better-managed” case scenario, just with the altered appropriate values.

(01) Access to firearms=
RANDOM UNIFORM(0, 0.024028, 0.001)
Units: **undefined**

(02) Access to substances=
RANDOM UNIFORM(0, 0.024028, 0.001)
Units: **undefined**

(03) Age=
RANDOM UNIFORM(0, 0.023135, 0.001)
Units: **undefined**

(04) Attitudes that disregard violence=
RANDOM UNIFORM(0, 0.024028, 0.001) + Patriarchy
Units: **undefined**

(05) Biological factors= INTEG (
Rate 1-Rate BF,
0)
Units: **undefined**

(06) Controlling behaviour from parents or caregivers=
RANDOM UNIFORM(0, 0.023902, 0.001)
Units: **undefined**

(07) Early or forced marriage=
RANDOM UNIFORM(0, 0.024028, 0.001)
Units: **undefined**

(08) Economic factors= INTEG (
Rate 4-Rate EF,
0)
Units: **undefined**

(09) "Economic, educational and health policies"=
RANDOM UNIFORM(0, 0.024132, 0.001)
Units: **undefined**

(10) Emotional bonding with parents=
RANDOM UNIFORM(0, 0.023902, 0.001)
Units: **undefined**

(11) Exposure to poor parenting practices=
RANDOM UNIFORM(0, 0.024028, 0.001)
Units: **undefined**

(12) Family dysfunction or separation=
RANDOM UNIFORM(0, 0.023902, 0.001) + Family honour
Units: **undefined**

(13) Family honour=
RANDOM UNIFORM(0, 0.024028, 0.001)
Units: **undefined**

(14) FINAL TIME = 100
Units: Month
The final time for the simulation.

(15) Gender=
RANDOM UNIFORM(0, 0.023902, 0.001)
Units: **undefined**

(16) Gender and social norms=

RANDOM UNIFORM(0, 0.024132, 0.001)

Units: **undefined**

(17) Gender equality=

RANDOM UNIFORM(0, 0.024482, 0.001)

Units: **undefined**

(18) "Gender-Based Violence"= INTEG (

(Biological factors + Economic factors + Personal factors + Religion and Cultural practices

+ Societal factors + Substace abuse)/6,

0)

Units: **undefined**

(19) Health=

RANDOM UNIFORM(0, 0.024221, 0.001)

Units: **undefined**

(20) Income=

RANDOM UNIFORM(0, 0.023902, 0.001) + Level of education

Units: **undefined**

(21) Income generation opportunities=

RANDOM UNIFORM(0, 0.024298, 0.001)

Units: **undefined**

(22) INITIAL TIME = 0

Units: Month

The initial time for the simulation.

(23) Legal action for sexual violence offences=

RANDOM UNIFORM(0, 0.024132, 0.001)

Units: **undefined**

(24) Level of education=
RANDOM UNIFORM(0, 0.024298, 0.001)
Units: **undefined**

(25) Level of poverty=
RANDOM UNIFORM(0, 0.024132, 0.001) + Population density
Units: **undefined**

(26) Marital status=
RANDOM UNIFORM(0, 0.024028, 0.001)
Units: **undefined**

(27) Matlreatment at a young age=
RANDOM UNIFORM(0, 0.023902, 0.001)
Units: **undefined**

(28) Mental health problems=
RANDOM UNIFORM(0, 0.023135, 0.001)
Units: **undefined**

(29) Multiple partners=
RANDOM UNIFORM(0, 0.024028, 0.001)
Units: **undefined**

(30) Normalisation of substance misuse=
RANDOM UNIFORM(0, 0.023135, 0.001)
Units: **undefined**

(31) Normalisation of violence and violent practices=
RANDOM UNIFORM(0, 0.024028, 0.001) + Patriarchy
Units: **undefined**

(32) Opportunuties for economic advancement=

RANDOM UNIFORM(0, 0.024132, 0.001) + Level of education
Units: **undefined**

(33) Pandemic and lockdown measures=
RANDOM UNIFORM(0, 0.024298, 0.001)
Units: **undefined**

(34) Patriarchy=
RANDOM UNIFORM(0, 0.024132, 0.001)
Units: **undefined**

(35) Personal factors= INTEG (
Rate 3-Rate PF,
0)
Units: **undefined**

(36) Population density=
RANDOM UNIFORM(0, 0.024221, 0.001)
Units: **undefined**

(37) Race=
RANDOM UNIFORM(0, 0.023135, 0.001)
Units: **undefined**

(38) Rate 1=
(Age+Mental health problems+Race+Sex)/4
Units: **undefined**

(39) Rate 2=
(Access to firearms+Access to substances+Gender equality+Health+Income generation opportunities
+Pandemic and lockdown measures+Social cohesion and unity+Social protection for victims
)/8

Units: **undefined**

(40) Rate 3=

(Controlling behaviour from parents or caregivers+Emotional bonding with parents +Exposure to poor parenting practices+Family dysfunction or separation+Family honour +Gender+Health+Income+Level of education+Marital status+Matlreatment at a young age +Opportunuties for economic advancement+Pandemic and lockdown measures+Witnessing violence between parents or caregivers)/14

Units: **undefined**

(41) Rate 4=

("Economic, educational and health policies"+Health+Income generation opportunities +Legal action for sexual violence offences+Level of poverty+Opportunuties for economic advancement +Pandemic and lockdown measures+Population density)/8

Units: **undefined**

(42) Rate 5=

Normalisation of substance misuse

Units: **undefined**

(43) Rate 6=

(Attitudes that disregard violence+Early or forced marriage+Gender and social norms +Multiple partners+Normalisation of violence and violent practices+Patriarchy +Sexual entitlement ideologies)/7

Units: **undefined**

(44) Rate BF=

0.021142

Units: **undefined**

(45) Rate EF=

0.024028

Units: **undefined**

(46) Rate PF=
0.023092
Units: **undefined**

(47) Rate RCP=
0.023902
Units: **undefined**

(48) Rate SA=
0.021142
Units: **undefined**

(49) Rate SF=
0.023739
Units: **undefined**

(50) Religion and Cultural practices= INTEG (
Rate 6-Rate RCP,
0)
Units: **undefined**

(51) SAVEPER =
TIME STEP
Units: Month [0,?]
The frequency with which output is stored.

(52) Sex=
RANDOM UNIFORM(0, 0.023135, 0.001)
Units: **undefined**

(53) Sexual entitlement ideologies=
RANDOM UNIFORM(0, 0.024132, 0.001)

Units: **undefined**

(54) Social cohesion and unity=
RANDOM UNIFORM(0, 0.024132, 0.001)
Units: **undefined**

(55) Social protection for victims=
RANDOM UNIFORM(0, 0.024028, 0.001)
Units: **undefined**

(56) Societal factors= INTEG (
Rate 2-Rate SF,
0)
Units: **undefined**

(57) Substace abuse= INTEG (
Rate 5-Rate SA,
0)
Units: **undefined**

(58) TIME STEP = 1
Units: Month [0,?]
The time step for the simulation.

(59) Witnessing violence between parents or caregivers=
RANDOM UNIFORM(0, 0.023902, 0.001)
Units: **undefined**