

## **FIRE DISASTER MANAGEMENT IN SOUTH AFRICA: LOOK AT STATISTICS AND IMPACTS**

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### **Abstract**

The existence of wildfires has been present since before humans, eventually, humans learned to control it. Today fire is used for warmth, hunting, gathering, agriculture, energy and so on. Fire has led to the evolution of flora and fauna of the world and the development of human society. Fire is both a natural and manmade disaster that causes a significant threat to life, property in residential, urban, rural areas, as well as industrial areas and the environment. Impacts of fire can be social, economic and environmental. Such as demolishing wildlife habitat, watershed and water supply damages, damage to property such as public recreation facilities, trails, campgrounds and signs that affect tourists, destruction of timber, degraded air quality and smoke-related illnesses. Fires when not controlled become disasters that should be addressed. This is done through disaster management, which can be summarised through the disaster management cycle that includes mitigation, preparedness, response and recovery. Disaster management of fire should be carried out in accordance with the Disaster Management Act, the Fire Brigade Service Act, the National Veld and Forest Fire Act and the National Building Regulations and Building Standards Act. Fire in South Africa is a usual occurrence. The National Disaster Management Centre recorded that in 2016/17 over 17000 fires occurred, destroying almost 5900 dwellings and resulting in the death of 142 people. Fires greatly affect informal settlements as well as other hazards they are poorly built and overcrowded therefore are vulnerable.

**Keywords:** Wildfires, Settlements, Statistics

### **Introduction**

Wildfires have existed long before humans appeared. Humans learned to manipulate fire to their advantage, but with it came a great deal of destruction. Fires can be both a comfort and a threat. Fires are both a natural and manmade; and can develop or escalate into disasters which can put human lives, assets and lifelines at risk. (Xin & Huang, 2013) (Pausas & Keeley, 2009) Fire can occur naturally and can play an ecological function in the pyro-sphere (Neary & Leonard, 2019) For a fire to ignite, the components of the fire triangle must be present at the site of the fire, as shown in Figure 1 below (MacDonald, 2017).

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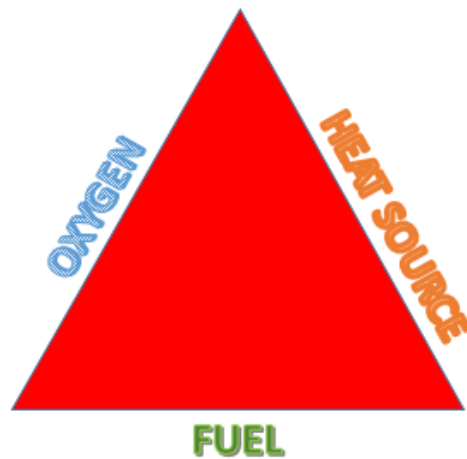


Figure 1: Fire Triangle. (MacDonald, 2017; Heikkila, et al., 2007)

Oxygen is usually available in the atmosphere and is in excess due to the presence of plants. Heat sources vary from cigarette buds, malfunction of electrical appliances, open flames, and natural heat sources will include lightning, volcanoes, and radiation from the sun. Fuels also differ from dried or fire-prone vegetation to paper, metals, oils, and so on. As the fire progresses it becomes simpler to categorise them. Fires are described according to the position they are burning in the forest. Ground fires, surface fire, understory or sub-canopy fire and crown fires. (Heikkila, et al., 2007) Fires can be easily classified by their fuels, which also aid in their dousing and treatment of victims. This classification differs according to the international standards used. The 3 most recognised are the American, Australian and European. (Rasheed, 2019; see Table 1 below for details)

With changes in the terrestrial ecosystem functioning, climate systems and an increase in human population and development we have seen an increase in fire occurrences. The majority of these fire hazards are related to human activities, mostly through carelessness or negligence. The fires enflamed by humans, half of them are caused by arson and negligence, while the other half is unknown (Moshashaei & Alizadeh, 2017; Kojo, 2015; Jhariya, & Raj, 2014). The number of fires that result from arson, recklessness or inattention is high showing a high probability that it will be disruptive and unrestrained. Fire disaster demolishes everything surrounding it, property, timber, animals and humans. Any disaster, more so fire causes great panic among the public which will lead to more damage and thus the panic during and in the aftermath of a fire disaster needs to be managed. (Masellis, et al., 1999)

Disaster management is organising, preparing, applying and executing procedures that facilitate action towards a disaster, this is done following the Disaster Management Act (DMA; South Africa, 2002). The DMA encompasses all the areas of the disaster management cycle which include prevention by reducing the risk and impact of a disaster. Examples of this include early warning system, implementation of policies such as National Building Regulations and Building Standards Act, raising community awareness and educating them on fire safety and doing continual training and testing ahead of time. (UNDRR, 2020; Khan, et al, 2008) Preparing for disaster incidences such as fire escape and evacuation plans in every building and areas, specific training courses and disaster simulation exercises are encouraged to all people, emergency health courses for the public. (Khan, et al., 2008; (Masellis, et al., 1999) Legislation in South Africa, which applies to the fire disaster management, will be described in this article

### **Legislation involved in the management of fires.**

#### **The Disaster Management Act and the Fire Brigade Service Act**

The Disaster Management Act (DMA) is the main legislation that governs disasters in South Africa, which advocates an integrated and participatory approach to disaster risks management in the country (DMA; South Africa, 2002)

Fuels	Zones	Australian Classes	European Classes	USA Classes	Extinguishers
Solid materials such as wood, paper or textiles	Residential areas, industrial areas, offices, schools, hospitals	A	A	A	Dry powder Wet chemical Foam
Flammable liquids which include diesel, petrol, paint and some organic chemicals	Garages, industrial areas, transport vehicles	B	B	B	Dry powder Carbon Dioxide Foam
Flammable gases which include liquefied petroleum gas	Residential areas, industrial areas, laboratories	C	C	B	Dry powder
Flammable metals such as sodium and potassium	Industrial areas and laboratories	D	D	D	Dry powder
Electricity	Residential areas, industrial areas, server rooms	E		C	Dry chemical/powder Carbon Dioxide
Cooking oils	Residential areas, commercial areas, kitchens	F	K	K	Dry powder Wet chemical

Table 1: Fire classes according to fuels. (Rasheed, 2019; Fast Fire Protection, 2018; United States Department of labour, 2020).

DMA is “a policy that upholds the bill rights as stated in Chapter 2, section 10, 11, 24, 26 and 27 of the Constitution of South Africa, these rights include the right to life, health care, food, water and social security, human dignity, housing and right to an environment that is not harmful to their health or well-being, an environment that is well protected”. (South Africa, 1996; South Africa, 1998; Vermaak & van Niekerk, 2004) The Fire Brigade Service Act (FBSA) is “the legislation for fire services responsible for the establishment, maintenance, employment, coordination and standardization of fire brigade services and all affairs connected to it”. (South Africa, 1987) The FBSA in section 2 describes that the board is responsible for the regulation of public fire services in South Africa, advising the government when called on and commissioning a committee that will aid in executing the regulations associated with the Act. (South Africa, 1987)

Unfortunately, this legislation is dated and needs to be revised. Primarily the municipal of a region can handle fire management better than the national and provincial government as they know where their vulnerability lies, however, the other spheres of the government should aid in the provision of a legislative framework that is standard nationally. As in section 155-part 7 of the Constitution, the national and provincial government have the authority to see that the municipalities are working soundly to carry out their responsibilities. (South Africa, 1996; NDMC, 2020) Section 8 of FBSA lists the powers of a fire fighter, they can command any member of the public that's between the age of 16 and 60 to help when carrying out their service in any situation. (South Africa, 1987) They can remove any person that might be causing discord or disrupting operations of the service. They can gain access into any building or location or vehicle without the owner's consent if there is a safety risk or for investigation purposes as well as prohibit entry into any of these places if there's still a safety risk. (South Africa, 1987) They can close down a road highway, road or pathway in the process of managing an incident. Because fire is usually unpredictable in terms of spread, intensity, behaviour and even location there's always uncertainty when it comes to adequate fire fighters available in each municipality or area because of this reason there are always various groups of workers waiting. (South Africa, 1987)

Chief fire officer, whose assignment is present in section 5 of the Act, is usually in charge of the fire department in their district, they're appointed by a controlling authority. (South Africa, 1987) Fire services work as local fire services, designated fire authorities, fire brigade reserve force and volunteer fire associations. The local fire services being the municipal fire department, designated fire authorities are any organisation or agency that can aid in the management of fires in any way, so these can be agencies adjacent to the services provided, fire brigade reserve force is temporary servers that can be appointed by the chief officer typically on a part-time basis, while volunteer fire associations are helpers to their community, under Chapter 2 of the National Veld and Forest Fire Act. (South Africa, 1998) Currently, in South Africa, a lot of the fire services are underprivileged as such they cannot provide this valuable essential service for their communities, because of this many fire services depend on reservists to provide services to their communities. (South Africa, 1987) (NDMC, 2014) (NDMC, 2020)

### **National Veld and Forest Fire Act.**

The purpose of this National Veld and Forest Fire Act (NVFFA) "is to prevent and combat veld, forest and mountain fires throughout the Republic" (South Africa, 1998). The Act encompasses the early warning system, mitigation, preparedness and response of fire hazards with the help of the community and landowners. Chapter 2 of the Act talks about of fire protection association. (South Africa, 1998) Fire protection associations (FPA) are formed in areas where their region is deemed to be vulnerable to the risk of fire due to areas with abundant vegetation and extreme weather. If an area does not have an FPA but the Minister considers it as vulnerable the Minister can intervene and call a meeting with people in that community. Chapter 3 of the Act requires the Minister to provide the National Fire Danger Rating System (NFDS) for the whole country. Fire danger rating system is achieved in association with South Africa Weather Services and various Fire Protection Associations, CSIR, DAFF, SAWS and WoF. (Matt Jolly, 2009)

The NVFFA in chapter 3 section 9 requires the NFDS to work constantly uninterrupted around the clock. The system is supposed to monitor the whole Republic, which is classified into the municipalities to simplify the monitoring and communication. (South Africa, 1998) All factors that affect fire are considered within the disaster management system, as such the system works with different models that mimic the ease of ignition and fire behaviour explain which will help with the early warning system. Section 10 of the same chapter tells us that communication between the Minister and the FPA of each region about the rating of fire danger should be frequent. (South Africa, 1998) And when fire danger is high the minister communicates to the public through the help of television, radio stations and newspapers. Other ways of communication can include websites, social media and mass texting. If the danger is high communication is more concentrated during that period. The communication should be clear and easy to read. The rating of the fire is divided into five groups which are represented by a colour, in every category the expected fire behaviour and measures that

would be needed to ensure fire suppression in each category (see details in table 2). (Willis, et al., 2001)

	<b>Danger</b>	<b>Fire Behaviour</b>	<b>Colour</b>
1	Insignificant	Fires might not start, if they do they will extinguish with no aid	Blue
2	Low	Fires will start but will spread slowly.	Green
3	Moderate	Fires are slightly easy to ignite and will spread, burning will occur on surface layers below trees.	Yellow
4	High	Fires will promptly ignite and spread, crown fires and short-range spotting.	Orange
5	Extremely high	Fires will effortlessly ignite and will spread in the crowns of trees as well as in surface layers, and long-range spotting will occur.	Red

Table 2: Classification of fire danger according to colour. (Willis, et al., 2001)

The FDS publicize areas where fires might happen or currently happening. Organisations that mostly use the system include FPA, farmers, conservation agencies, the public, NDMC, local government, municipalities and the SA Defence force. The information is spread through the media and internet. (Willis, et al., 2001) Chapter 4 and 5 are directed to landowners. (South Africa, 1998) Chapter 4 speaks on the prevention and mitigation of fire disaster through making and maintaining fire breaks in their land. Fire breaks are anything that can halt the movement of fires in anyway. This means that there are different types of fire breaks. Fire breaks are when a strip of land is cleared of all kind of vegetation, fuel, and only bare ground is left. (Ascoli, et al., 2018) The landowners are expected to communicate and coordinate with the interconnecting landowners and the members of the FPA for the construction and maintenance of these firebreaks. The fire breaks are supposed to be effective in their prevention of fire spread as such no flammable matter is supposed to be present within that firebreak. The firebreaks must be carried out in a way that still ensures conservation of the environment, therefore it is done in a way that does not cause damage to the land such as soil erosion or damage of plants or trees that are protected by law. (South Africa, 1998)

Chapter 5 of the Act dictates that landowners are required to have fire-fighting equipment on their property in case of an active fire. (South Africa, 1998) The landowner in an area where a fire is likely to occur should have fire-fighting trained personnel, equipment and protective clothing. The landowner is expected to notify and aid fire-fighting officers to stop the fire in case of a fire occurrence whether on their property or close to them. If a fire officer is present, they become the ones in charge of fire disaster response, they can also order anyone who is between the age of 16 and 60 to help with the fighting of a fire. But where a fire fighter officer is not available a forest officer can do

the above-mentioned duties. (South Africa, 1998) However, any person that suspects a fire or sees one is allowed to enter any land as well as the premises without permission, destroy something that can further fuel the fire, remove any people or property that may cause further harm or may be in danger. As a community, the landowners are required to coordinate and work as a system. (South Africa, 1998)

### **National Building Regulations and Building Standards Act**

The National Building Regulations and Building Standards Act (103 of 1977) aims to advocate standard law regarding the construction of buildings, the establishment of a building standards and all other connected matters. The National Building Regulations (NBR) are only available from the South African Bureau of Standards. (South Africa, 1977) They give guidelines to any person that intends on building a structure. The NBR have 23 chapters that touch on different matters of building such as structural design, floors, stairways and refuse disposal to name a few. The important chapters to focus on for fire management would be lighting and ventilation, fire protection, space heating, fire installation and energy usage. (South Africa, 1977) The South African National Standards (SANS) that are associated with the construction of buildings are assembled by the South African Bureau of Standards (SABS). This document is SANS 10400, the Code of Practice for the application of the National Building Regulations (NBR). It is a document that aids architects, engineers, land surveyors on how to understand the regulations, by including part of the regulations then a commentary clarifying them so that it adheres to the law. As such it is important to note that the Act should be read in conjunction with the SANS. (South Africa, 1977)

The Act declares that construction of a building cannot commence without the owner of the building applying for approval. The permission is granted or rejected by the local authority through the recommendation of a building officer. (South Africa, 1977) The application includes crucial information of the owner, plans and particulars of the construction process drawn according to the terms of the Act, along with a report of a fire chief officer in terms of fire protection plans. Section 7 cites that authorisation of the construction of the building is given when an application has been found to comply with the set requirements of the Act. SANS 10400 has several sections that detail the regulations, nevertheless, we will discuss those linked to fire safety starting with Part D: Public safety. This section ensures clear and accessible pathways in private homes and public buildings. (Building Regulations, 2020) Part O: Good lighting and ventilation should provide safe rooms when people enter them. In the event of a fire, it is crucial to have good lighting so that you can see signs and directions of evacuation or response systems. Ventilation can help to clear smoke which in some cases can be more dangerous than the flames of a fire.

Part T: Fire protection guarantees that the design, construction and equipment of buildings should minimize fire hazards so that people within the buildings are protected, the spread and intensity of the fire along with the smoke within the building and neighbouring buildings is contained and decreased. (South Africa, 1977) (Building Regulations, 2020) All equipment and systems involved in the mitigation and response of fire are well ordered. Fire protection is ingrained with almost every part of the building from the roof, ceilings, walls and floor coverings to exit doors, feeder routes, smoke control and building materials and so on. Part V: Space heating. In this portion, the legislation instructs that any system of space heating should be designed, constructed and installed in a way that it will work proficiently and safely. These systems should be fashioned from material that is non-combustible and in a way that allows for smoke or other toxic gases produced be removed carefully. Part W: Fire installation. This section covers the response action of a fire hazard for building. It requires that fire installations be connected to a communication pipe of water or another alternative supplied and approved by the local authority. (South Africa, 1977). (Building Regulations, 2020) These Acts are not the only legislation that are involved in the management of wildfire, however, they are the ones necessary in this context.

### **Impacts of fires**

Fire has been around for as long as plants, as such fulfilling the fire triangle, oxygen and fuel can originate from plants and ignition from lightning, radiation, falling rocks or other natural means. Fire aided the structure of most ecosystems as well as progressed the evolution of the world the fauna and flora of the world. (Pausas & Keeley, 2009) In early times natural wildfires were enough for forest and wildlife management but with the involvement of humans through various ways such as agriculture, deforestation, global warming came prescribed burning (Bond & Keane, 2017). Prescribed burning maintains ecological health. Fire should be controlled carefully so that it is beneficial and does not cause destruction. Prescribed burning also known as controlled fire is when a land manager or someone with authority and knowledge ignites a fire to surrounding vegetation in an area to achieve a certain goal. Prescribed burning is a very complex technique that relies on frequency, intensity and season for it to work efficiently. (Fernandes & Botelho, 2003) (Waldrop & Goodrick, 2012).

Prescribed burning cleans the forest floor from dead plants and fuel loads while producing nutrients to the forest, the soil becomes more fertile allowing for plants and trees to grow healthier, providing sustenance for wildlife. It also clears and removes trees and plants that are diseased, surplus or have too much covering that blocks any other plants that may be underneath them. Prescribed burning is an instrument that can be used to control the overpopulation of animals as well as providing habitat and nourishment to the organisms within the region. (Rodina, et al., 2020; Grodsky, et al., 2016). As humans familiarised themselves with fire, as such manipulate and command it. It became a tool to them that allowed them to gather, hunt, cook food, used it for light eventually leading to the human development we have today (Bond & Keane, 2017; Gowlett, 2016).

However, with all this mastery over fire sometimes it can get out of control causing devastation in its path. The impacts of fires can be economic, social and environmental. This is because the hand of fire reaches beyond just the enclosure of the burn. Forest fires affect the environment physically, chemically and biologically. When wildfires occur it's usually in a forest saturated by vegetation fuelling it. If a fire isn't controlled, it consumes everything in its path. It destroys its fuel, vegetation, which can range from weeds, grass and large trees, to even huge rainforests. These make for timber, paper and so on. The destruction is based on the spread and intensity of the fire and well as the area in which the fire blazes. Wildfires can lead to reduced land cover, increase soil erosion along with an increase in overland flow or surface runoff. This can lead to contamination of water sources such as rivers and dams, which can further induce floods or cause health problems to all life forms that then uses these polluted water sources. (Li, 2019)

Likewise, if fire burns in an industrial or residential area residential assets might be lost, furniture, important documents, valuable and sentimental possessions and sometimes whole building contingent to the intensity of the fire. Industrial or residential areas are typically densely populated and in the event of a fire there is a higher risk of human fatalities. When fire burns smoke is realised in the air, this, in turn, causes a decrease in air quality. Smoke in the air will affect people's eyes, nose and throats. The more toxic the smoke the more harm it could do. Toxicity of the smoke is subject to the material that is being torched, this can differ from soil, crops, wood, chemicals, plastics, fabrics, metals and so on. There are significant long-term effects caused by fire on human health that affect the respiratory system and cardiovascular system. (Li, 2019; Hirschberger, 2016)

### **Global Impacts**

Fires are common around the world. In 2015 the USA had 1 945 500 fire incidents and 3 250 fire deaths, Sweden 22 785 fire hazards and 110 deaths, Russia had 145 900 fire occurrences with 9 405 accompanying deaths comparably Finland had 11 220 fire episodes and a small death number of 74, the Netherlands had 125 200 recorded fire events with 81-minute deaths. (Brushlinsky, et al., 2017) The available fire statistics in South Africa show an enormous death toll, injury, and damage caused by fires. In 2000 the number of fires was 38 000, with almost 200 loss of lives and R9 billion in financial loss. In 2010 about 26 000 fires occurred with the human loss of around 225 and a financial loss of R 1 billion. In 2015 the number of fires was 45 000, with 436 fatalities and financial loss at R2 billion. (National Fire Statistics, 2011) Some recent fire disasters that have been recorded by the NDMC in 2016/17 state that over 17000 fires occurred, destroying almost 5900 dwellings and

resulting in the death of 142 people. (Western Cape Government, 2017). Though the numbers show fluctuations, they are still high, and mitigation should be carried out to prevent any more loss.

### **Stakeholders involved in Fire Statistics**

#### **National Disaster Management Centre**

The National Disaster Management Centre which is governed by the Disaster Management Act. (South Africa, 2002) The Act aims to carry out disaster management, which is the prevention, mitigation, response and recovery, of any and every disaster in the country. Under the NDMC is the provisional disaster management centre, which is copied at the municipal disaster management centres. (South Africa, 2002) The NMDC is responsible for dealing with all issues involving disasters and their management. Some of these include managing private sector and non-governmental organisations, institutions, communities and individuals involved in a disaster, make authorisation of any usage involving funding of disaster management and endorse recruitment, training and participation to name a few. The NMDC must act as a storehouse for all information regarding disasters and disaster management as well as a channel for this information. This involves collection, process, analyses and the distribution of information all about disasters. (NDMC, 2019)

#### **Fire Brigade Service**

The National Disaster Management Centre is also accountable for the administration of the Fire Brigade Service Act as well as the Fire Brigade Board. It also helps with upholding and replenishment of its regulations. (NDMC, 2019)

#### **Department of Agriculture, Forestry, and Fisheries**

The Department of Agriculture, Forestry, and Fisheries (DAFF) is the custodian of the National Veld and Forest Fire Act (Act No. 101 of 1998) (NVFFA). The main aim of this Act is to prevent and combat veld (bush) fires, forest, and mountain fires throughout the Republic. The act regulates the formation and running of fire protection associations, which oversee everything related to fire management. There are various fire protection associations in South Africa these include Fire Protection Association of Southern Africa, Cape Peninsula FPA, Working on Fire (WoF) to name a couple. The FPA can also be assembled in conjunction with fire control committee, conservation committee, disaster management agency, catchment management agency and voluntary association that have been established under different Acts.

The NVFFA is also responsible for the fire danger rating system. Fire danger rating contributes to the mitigation and preparedness of fire management. In an effective disaster management system, an early warning system is a vital component. (South Africa, 1998) Fire danger rating is supposed to encompass the whole country taking into account the different factors of fire which are topography, weather conditions, climate and type of vegetation. The fire danger rating system is directed with the help of South African Weather Service. (South Africa, 1998) DAFF is “also responsible for the collection of veld fire statistics across the country, and it does this through the help of several systems, which include National Veldfire Information System (NVFIS), Advance Fire Information System (AFIS) owned by the Council for Scientific and Industrial Research (CSIR)”. (DAFF, 2010) The aid of South Africa Weather Services (SAWS), is the leading early warning systems for fire disasters are Common Alert Protocol (CAP) Web Application and the Fire Danger Index (FDI) Application, which provide information daily. As a result, it would be easy to record any incidences that would have occurred. The Fire Brigade Services and South African Police Services (SAPS) should also be mentioned as stakeholders involved with the statistics of fire as they are involved in the mitigation and usually contacted as the first responders. SAPS is called to respond to calls made in cases of unrest, accidents, and various hazards which can in most cases can turn into fire hazards. A large chunk of the hazards is produced from transportation vehicles, and for this reason, the Department of Transport should be considered participant. (Alexander et al., 2015)

#### **Fire Statistics**



Fires are widespread across South Africa throughout the year and are highly likely to occur during the fire season, which varies with geographical location. (DAFF, 2012; Strydom & Savage, 2016) Fire is an expensive hazard which can culminate into more losses than costs, therefore it is more effective as an individual and a nation to capitalize on fire management rather than lose millions and billions because of neglect (for South African context, please see Figure 2 on the next page). The cost of fire management includes mitigation measures, fuel management, regulations and building codes, insurance, among other things. Fire disaster outcomes include human deaths, injuries, health, psychological and environmental impacts, and agricultural losses, while indirect costs include general economic impacts, evacuation costs, supply chain impacts, the economic decline of the community, and government service interruption, including other things. (Thomas, et al., 2017)



Figure 2: Financial losses caused by fire. (Fire Protection Association of Southern Africa, 2015)

When a fire occurs, its economic impacts are wide, each year South Africa loses millions of rands to this disaster. In 2003 there was a loss from fire damage of close to R5000 million, which was 4% of the country's GNP, as the years have gone by the financial losses have lowered, this shows some intervention taking place (see Figure 2 for details). If it happens in agriculture or forest industry it destroys, crops, acres of vineyards, livestock, timber, indigenous plant life and animals. In a human settlement, it displaces people, affects their health and destroys their homes. Businesses also suffer the loss of stock, especially in offices, warehouse, storage facilities or manufacturing plant. The municipal infrastructure is also affected such as destruction of schools, damages to the sewage, water system and electricity. (Santam, 2017). (Forsyth, et al., 2019). Financial losses can be further broken down to evaluate the financial losses according to the different sectors, as shown in Figure 3 below.

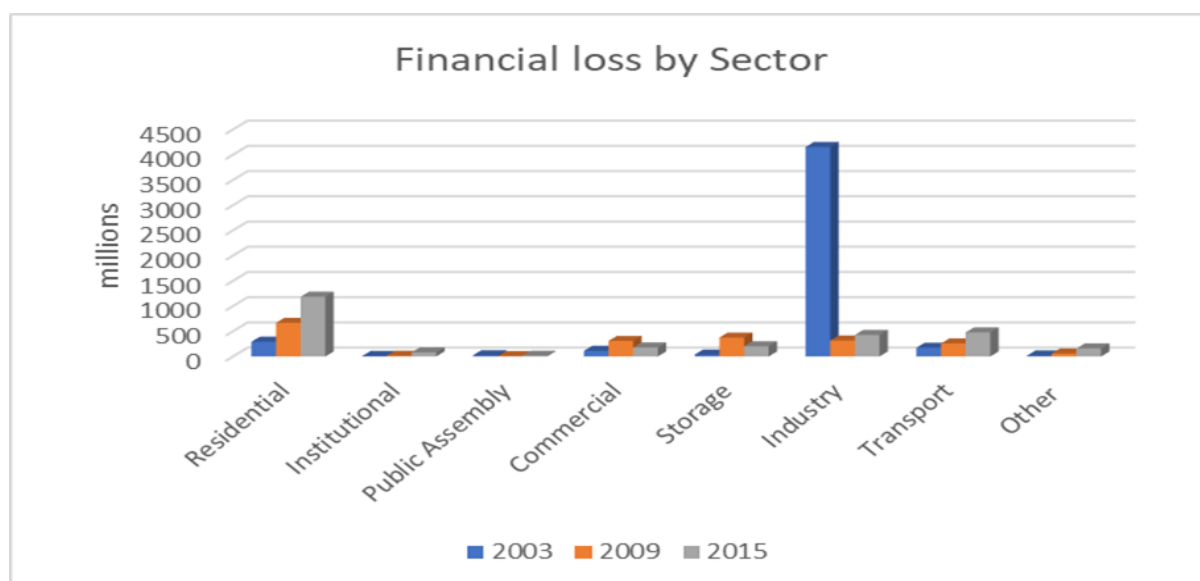


Figure 3: Financial loss from fires divided by sectors. (Fire Protection Association of Southern Africa, 2015)

The sectors that should be carefully considered are the Industry and Residential sectors based solely on the numbers shown in figure 3. The industry sector contributes highly to the total South African economy, an estimation of about 26% of the gross domestic product in 2019. (StatsSA, 2020) Therefore the industry sector is vital for the growth and stability of South Africa's economy as a result it is necessary for this section to be extremely policed. The industry sector in this context will consist of manufacturing, mining, agriculture, construction to name a few.

The high fire rates in the industrial sector will be caused by hot work such as welding, burning and heating, combustible dust, which can come from food, chemical, metal, plastic manufacturing, even materials that aren't necessarily flammable when they are larger can be combustible when they are in their dust form. Electrical hazards from wiring that exposed, overloaded outlets, extension cords, flammable liquids and gases that can be used as a fuel source, equipment and machinery that is not well maintained, which can cause an ignition through friction. Figure 3 shows that from 2003 to 2015 there is a decrease in fire occurrences in the industry sector this can be credited to increased building regulation and codes as well as better training of employees and specialists, yet the same number seemed to have slightly increased in the residential areas which can be because of the rise in population, which is likely to lead to an increase in the total count of the formal and informal settlements. However greater care should be taken in the sector that has higher risk, these would be the sectors that involve a large volume of the general population such as informal settlements as shown in Figure 4.

The above graph (figure 4) shows fire deaths in more specific sectors. Firstly, informal dwellings have the highest numbers of above 200 people dying, followed by formal dwellings and then vehicles. These informal settlements are vulnerable to many hazards, this is exacerbated by their location, inferior building materials, and inadequate road access for emergency vehicles to name a few. There is also a very high number of road accidents and deaths in South Africa, in 2015 there were 12 944 road fatalities according to Road Transport Management Cooperation. (ITF, 2016) Fire risk is influenced by a variety of socio-economic factors such as the increase of urbanization, therefore when looking at managing fire, it is important to look at the relationship between fire occurrence and its socioeconomic impact as this will help with fire protection and fire risk assessment. (Boadi et al., 2015)

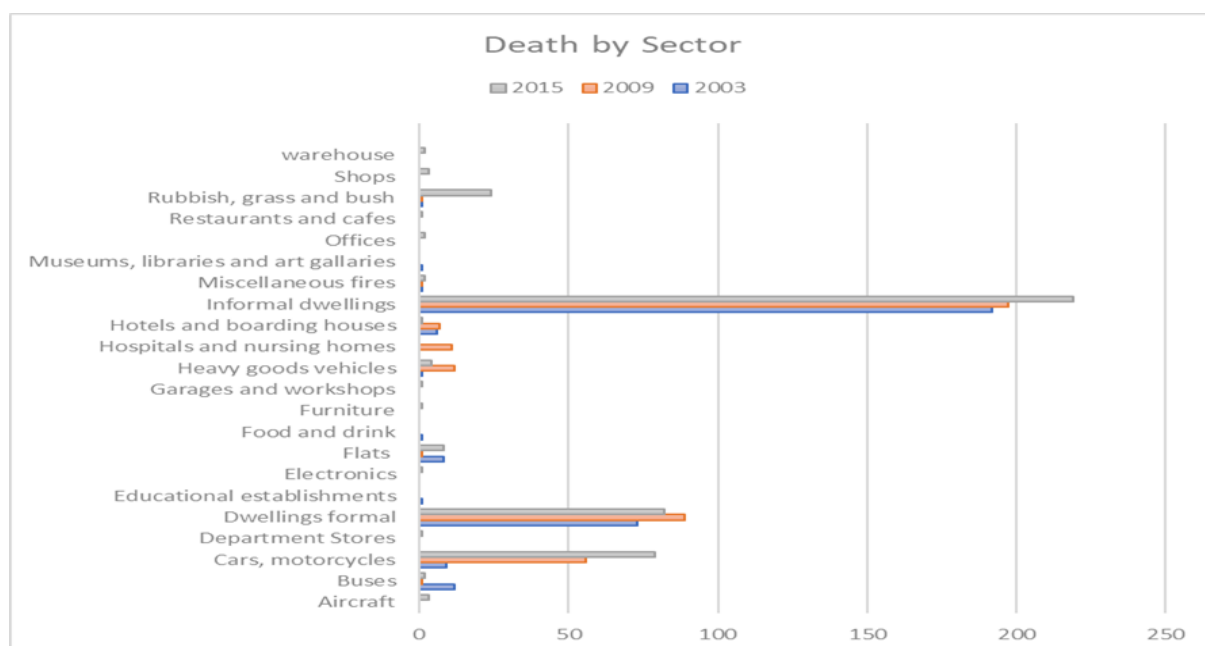


Figure 4: Death from fires divided by sectors. (Fire Protection Association of Southern Africa, 2015)

### Informal Settlements

With the growth of the SA population there also has been a growth of urbanisation and the related rural-to-urban migration of the South African population which cause a large number of people to move from rural areas to go to urban areas but because of the government and other underlining factors such as poverty, education, the rising of cost of living instead of living in good proper approved houses they stay in houses that are ill built and lacking. (Chikoto, 2009) These can also be defined as unplanned settlements that do not meet the rules and regulations of South Africa’s National Standards. Informal settlements are characterised by high population density, poor public and private investment, lack of service delivery, high crime rate, the fast spread of communicable diseases and so on. (WHO, 2020) (Dodman et al., 2018).

The General Household Survey show that in 2003 the number of household in the Republic was 11459 million while in 2009 it was 13128 million then in 2015 it was 15307 million and in 2018 a further increase of 16671 million these numbers attest to the increase of population from 46461 million in 2003, 54750 million in 2015 and lastly 57458 million in 2018. (StatsSA, 2020) Informal settlements are at a risk of plenty of hazards and disasters such as fires, epidemics, flooding and earthquakes due to being poorly built and the high population densities of these areas. Fires in informal settlements are a common occurrence. Khayelitsha fire in January 2013 that killed 5 people and left 4000 homeless, in Kayamandi, March 2013, a fire occurred that killed 2 people and left 4500 people homeless, these are just a few examples as the list is never-ending and should be managed. (Walls et al, 2017). Also, these areas have limited or non-existent access to sanitation, water and electricity which increases exposure and risk to these regions. The communities that occupy informal settlements are mostly dominated by the vulnerable, these people have low education, are from low-income families, have family members with disabilities and have children of ages 0-5 years, thereby being further disadvantaged. (SERI, 2018)

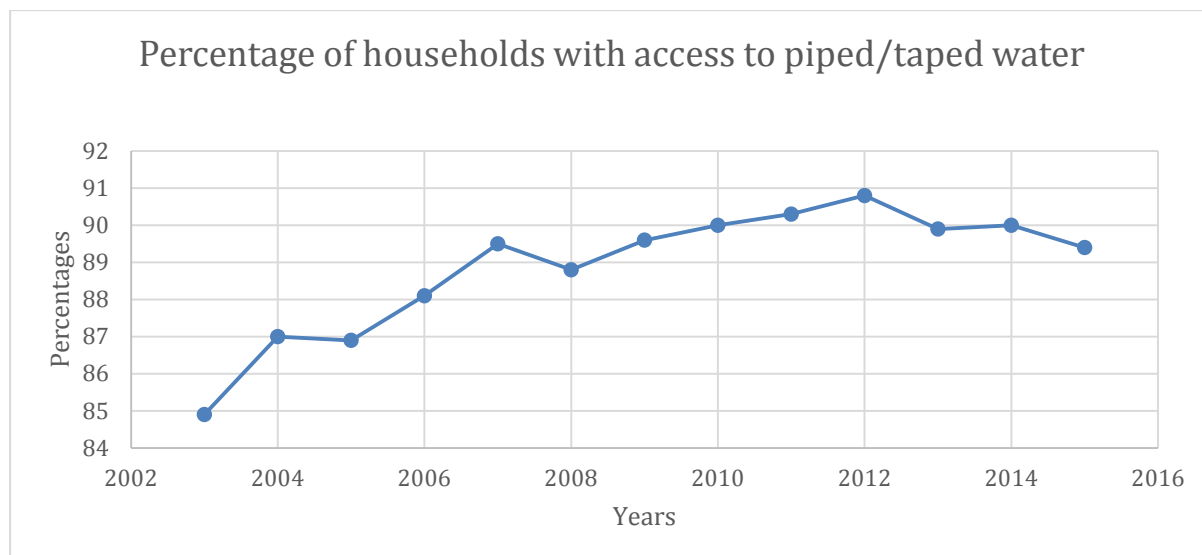


Figure 5: “Percentage of households with access to piped or tape water”. (StatsSA, 2016)

Access to water is necessary in each and every household but Figure 5 points out that this is not so in South Africa. Water, which is also important for sanitation purposes, is vital in case of a fire. Several households do not have access to water within their households (see details in figure 5), particularly in informal settlements obtaining water is through communal water sources. A community needs to have access to clean and healthy water on site. Reliable sources of water are piped water or a borehole on site. Other sources of water include rainwater tank on-site, this would be good in the rainy season only, however it still needs to be sterilised for consumption. Neighbours’ tap and communal taps or borehole or water tanks might not be feasible for the disabled, the elderly and those that are too young in case of an emergency or after hours. The remainder are natural sources of water, flowing waters such as streams and springs are fairly safe with stagnant waters like a dam or pool should not be ingested without being sterilized, however in the event of a fire the water can be used to douse it. (StatsSA, 2016) (StatsSA, 2019)

Electricity is not only a necessity for everyday functioning but if not managed properly or other substituted by other sources of energy there is a higher fire risk. Only 84.7% is of SA households is connected to the main electricity supply (StatsSA, 2016). In 2018 we see that most of the lighting, cooking heating water and space is achieved through electricity from the main supply. Other sources of energy include gas, paraffin, wood, coal among others. These are however all potential fuels for fires that can cause class A, B, C and F fires. (StatsSA, 2019)

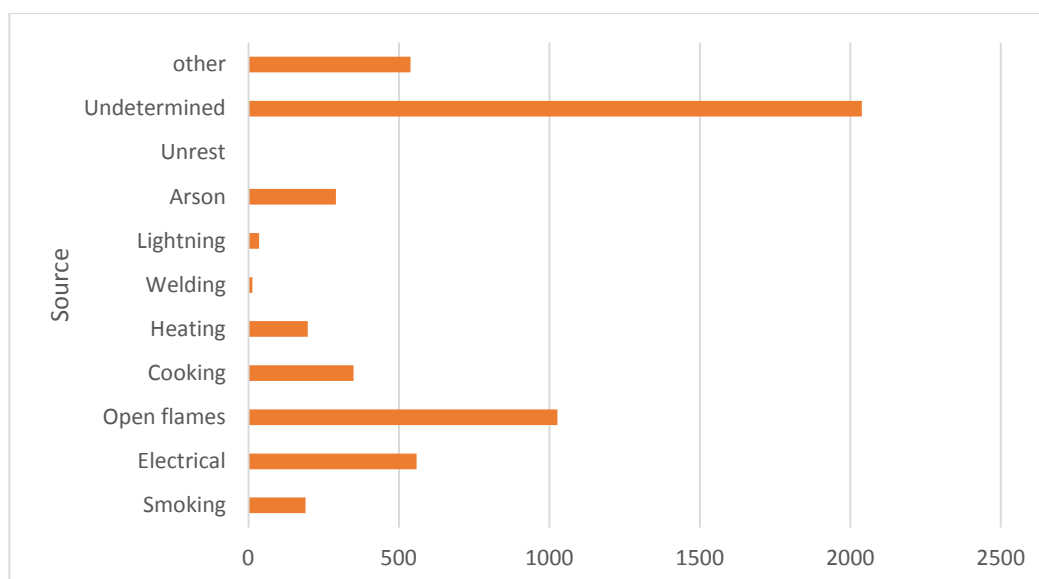


Figure 6: Numbers of fires in informal settlements from different sources. (Fire Protection Association of Southern Africa, 2020)

Unfortunately it is more difficult to manage fires in informal settlements, this is because of overcrowding, lack of knowledge and inadequate basic services. Informal settlements are mostly do not have electricity because of the location they are staying or that they cannot afford it. As a result they gain electricity through illegal means, this in itself becomes a large fire risk (see details in figure 6). (Gaunt et al., 2012). Figure 5 shows that the sources of fires in informal settlement cannot be totally eliminated because that is how they survive, such as cooking, heating and welding, however they should be educated on how to contain these fires that will likely occur.

Informal settlements are usually on built on illegal or unused land, the construction process is frequently rushed, with little to no planning. This is done quickly to not draw attention which can attract the authorities. Since this land has not been permitted for use by the government, resources are not distributed to this location. As a result, resources there is lack of basic services, such as electricity, paved roads, streetlights, waste management, drainage systems or sewage system, identification numbers houses and most importantly in the case of a fire, fire hydrants around that area. (SERI, 2018)

These houses and shacks are built close together to avoid attention as well as save land for the next person. These people lack security, so they live in a state of constant fear of eviction. The closeness of these houses causes overcrowding which makes it a favourable environment fire spread therefore in case of a fire more than one compound is affected. This also makes it difficult for extended when there has been an increase in the number of family members which is why these areas are densely populated. In addition to this, these buildings are not well ventilated or lit and sometimes are even without windows. Different materials that are used on the structure cause these houses to be extremely cold during winter while being extremely hot during the summers. Ventilation is needed to reduce damage in a fire incident, if people are trapped in building ventilation can give them a chance at survival by removal of carbon monoxide. (Chikoto, 2009), (SERI, 2018). Informal settlements typically constructed using cheap and available material, these are can be industrial by-products that are unwanted or have been sold at a much cheaper price. Shacks are built from timber, corrugated metal sheets, fibre cement, plastic, cardboard material or a combination of these materials. In most townships, there is the presence of wooden shacks and corrugated iron held together by plastics and scraps of wood. (Chikoto, 2009)

Some shacks are constructed fast, available, cheaper and easier to build, the houses are valuable for the price. Wood is also a good insulator which provides warmth for winter and coolness for summer. Also, when wood material burns some of the structure can be preserved because the char forms a sort

of protection to the unburned portion. However, more defence is needed than the material of the building. As fire safety is multi-sectoral, it involves fire detection, suppression systems, exit routes in case of a fire and so on. (Chikoto, 2009) Other shacks are made from cardboard which is made from recyclable material therefore making them environmentally friendly. Cardboard houses are cheaper and energy-efficient material and are expected to be used more in the future because of this. However, they are easy to burn therefore it is important to equip the building with fire safety measures. (Chikoto, 2009) Other shacks are made from straw and cob. The straw is put between the walls and provide insulation, the cob is a material that is made from clay, sand and straw; thus, the material is environmentally friendly. This material is most commonly used for traditional houses. The standard of buildings found in informal settlements can be improved if proper regulations are followed. These regulations are provided by the National Building Regulations and Building Standards Act (No. 103 of 1977)

## Fire risk assessment

When dealing with fire mitigation and preparedness, it is important to look at the fire risk assessment of every region. If there is a higher risk of an area, resources and more effort must be put in that community to decrease the probability of a fire disaster taking place. The fire statistics provided by the Fire Protection Association of Southern Africa (see Figure 7 for details).

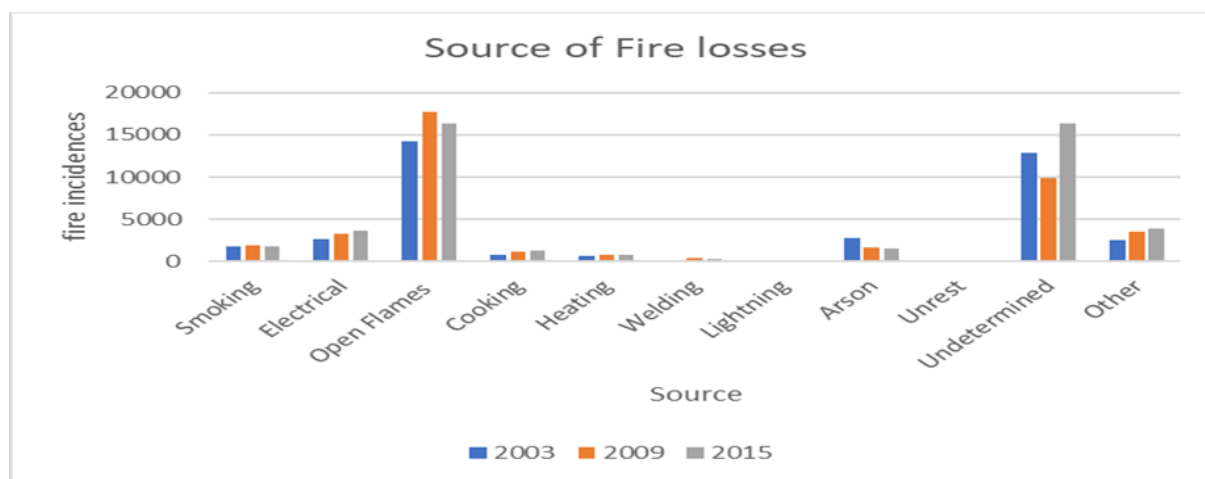


Figure 7: Sources of fire loss. (Fire Protection Association of Southern Africa, 2015)

Figure 7 indicates that the highest source of fire hazards comes from open flames (see Figure 7 for details), which are mostly caused by negligence. This shows how important fire awareness and education is to reduce the number of fires that occur. Open Flames, smoking, arson, heating, and lightning will fall under class A of the fire categorization with numbers of close to 200 through all three years (see Figure 7 for details). Comparing with the other sources, it can be observed as insignificant, but the concern is that it is extensive and cause massive harm. Arson and cooking will fall under class B, or F depending on specific fuel is being utilized. Then the electrical fires will fall under class C.

The different statistics show how destructive and the devastating fire is, therefore, it is important to strengthen fire management, it is also important to carry out a risk assessment analysis so that the necessary resources are put where they are needed most. South Africa has 52 district municipalities. According to the Fire Brigade Services Act, 1987 (Act No. 99 of 1987) these municipalities are responsible for the performance of the fire brigade in each district. It is important for community and fire services to have a relationship because communities are at the coalface of fires and often bear the brunt of unrestrained fires. Different communities have different levels of vulnerability according to social, economic, and environmental factors. Some communities have a greater population density than others. Some communities have more informal settlements than others. Some communities have more agricultural land that can be a prospect for fuels, and so on. Communities with higher levels of

human development index (HDI) are more resilient than those with lower HDI. Therefore, a risk assessment is crucial for every specific region. By looking at the risk equation, it is possible to calculate how high the risk of an area is. (Correa et al., 2011)

Risk can be calculated as  $\text{Hazard} \times \text{Vulnerability} / \text{Capacity}$  to cope. It is important to know all the factors that fall under these different categories involved in the computation of risk. (Forsyth et al., 2015)

Vulnerability embodies different types of deprivation such as isolation, poverty and powerlessness to name a few. (Chambers, 2006). The term of vulnerability, in the most general disaster risks management sense, can be defined for a social system or a group of people, assets and lifelines, and ultimately vulnerability is the embodiment of the susceptibility of the damaging collation of the hazard and disasters (United Nations, 2009). It is associated closely with disaster exposure. Exposure is people or assets present in the hazard zone that is subject to loss or damage (United Nations, 2009). South Africa is subjected to recurring droughts that vary in the area and time they occur. Drought is a creeping phenomenon which advances slowly over a long period and can have devastating impacts on people's lives and livelihoods. By the time it is fully in effect that when people want to respond. With the onset of drought comes a different environmental effect that enhances fire risk, such as the loss of water and atmospheric moisture, which can also lead to dry vegetation. (Department of Agriculture Forestry and Fisheries, 2016) Climate change has an immense impact on the risk of most, if not all, climate-related and meteorological hazards. (UNISDR, 2017) Socio-economic vulnerability includes the age, sex, economic status, and disabilities of those in the community. The elderly, infants and females are more vulnerable than males and adults, while at the same time, those that are poor are more vulnerable than those with high-income houses. (Ziogiannis, 2009) The population is also an important factor when looking at risk assessment, and a larger population is more vulnerable than an area with lower population density (see details in figure 8).

<b>Hazard</b>	<b>Vulnerability</b>	<b>Resilience</b>
Fire Drought	Drought Climate change Age Sex Economic status Location Physical and mental wellness Seasons and time Education Population density WUI	Government policy and frameworks Building regulation Infrastructure durability Fire department capability Monitoring and evaluation Human Development Index

Table 3: Different factors of the risk equation

As shown in Figure 8, the size of the South African population has a steadily increased between 1995 and 2015, but the number of fires fluctuates throughout the years. In South Africa, there are three main fire-prone ecosystems, which are grasslands, savanna, and fynbos biomes. There has been an increase in human and housing development at the wild-land urban interface, mostly at the urban fringes of towns and cities. This considerably increases the population's vulnerability to fire disasters. (Forsyth

et al., 2015) Going forward, this will have to be taken into account in the development of housing and human development in South Africa, focus on local disaster capacity in fire disaster management will have to be increased as well. Tools such as the firefighting training for population at risk and the volunteer fire fighting associations will have to be strengthened across South Africa.

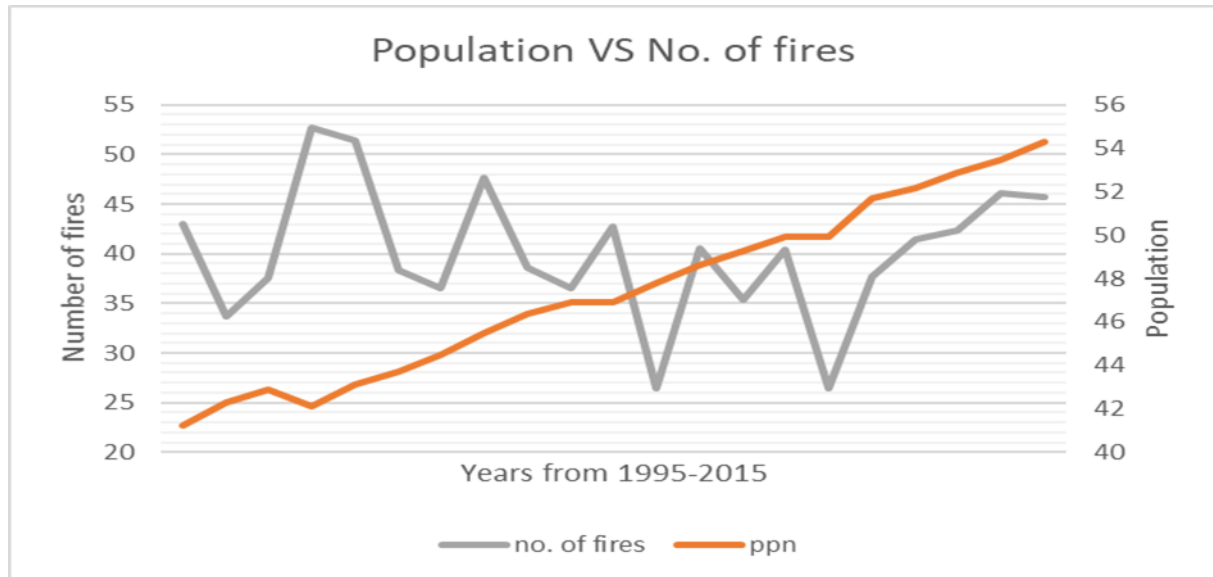


Figure 8: Comparing the population to the number of fire occurrences. (Fire Protection Association of Southern Africa, 2015)

### Conclusion

From the data above we can conclude that from 1995 until 2015 that fire incidents have been on the rise, this upsurge must be curtailed to prevent damages, loss of lives, assets and livelihoods. In the data, an undeniable trend is fires have become more human-induced rather than a natural phenomenon meaning that precautions can be put in place to significantly reduce the number. If all the stakeholders work together this can be an achievable goal.

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