Abstract

Background/Objectives: To gather the information on the natural disasters occurred Worldwide from the year 2004 to 2013 Average and 2014 and emphasizes on the disaster type which has severely affected the continent Asia, particularly, Malaysia. Methods: This paper collects all the information about major overflows in the history of Malaysia and gathers the facts about the official flood loss estimates for the selected major flood events from the year 1967 to 2012. It further provides information on the general causes and effects of floods and explains about the flood mitigation measures being used in this region. Additionally, it explains about the allocation of funds for flood mitigation measures by the Malaysian government under the Malaysia plan (1971 to 2020) and enlightens the responsibility of the government agencies accountable to the mitigation measures during the flooding conditions. Findings: Experiences from past floods, demonstrate that a common hazard which causes risk of death or serious injury to the people is due to the instability of vehicles in floodwaters. Therefore, the stability of vehicles during urban flood events has aroused recent interest from the Environmental Agency in the United Kingdom and other flood management authorities around the World. However, it is still believed that there is a need of an Integrated Smart Alarm System that can be used in the flood prone regions to minimize the vehicle related fatalities. Application: To provide researchers, government agencies and decision makers etc., an overview on the most notable disaster type which has severely affected the Malaysian region.

Keywords: Disasters Worldwide, Major Overflows in Malaysian History, Vehicle Related Fatalities

1. Introduction

The definition of disasters defined by the Malaysian National Security Council (MNSC) directive 20 (2003) states that “an emergency situation that will cause the loss of lives, damage property and the environment, and hamper local, social, and economic activities”. During the period of 1947 to 1981, the World witnessed a total of 554 hydrological disasters (floods and cyclones) and 208 geological disasters (earthquake, volcanic eruption and landslides). Within these two categories floods were the most frequent natural disasters followed by tropical cyclones and earthquakes. In the 20th century, floods alone have been reported responsible for the death of 08 million people Worldwide.

Figure 1 shows the number of reported disasters and victims from the year 1990 to 2014. Particularly in the year 2014, a total of 324 disasters were reported which affected nearly 141 million people Worldwide. Table 1 shows the regional figures about the occurrence of natural disasters and its impact by each continent. Globally, among 324 natural disasters that occurred in the year 2014, the hydrological disasters (flood, landslide and wave action) took the largest share of 153 events (47.2%) out of which 65 events were reported to occur in the continent Asia. In the same year, the number of victims affected by the impact of hydrological disasters Worldwide were counted to be 42.28 million out of which 37.10 million victims were reported from the continent Asia which is indeed alarming. Similarly, the estimated economic loss (US $ billion) caused by the hydrological disasters altogether in the entire World in the year 2014, was estimated to be 37.39 US $ billion out of which 29.42 US $ billion were to be borne by the continent Asia. Moreover, the Average (2004 to 2013) result
also shows that the continent Asia has remained constantly prone to hydrological disasters which had destructive impacts on it. Additionally, among the hydrological disasters, floods are said to be most lethal when compared to any other natural disaster type as shown in Figure 2.

Floods can effectively be described as natural disasters that affect, as well as is affected by human activities, particularly, physical development. It is a progressive abnormal increase in the elevation of the surface level of a stream's flow until it reaches an extreme height from which the level gradually drops to what was its usual level.

2. Floods History in Malaysia

Malaysia is located in Southeast Asia with an area of nearly 330000 km². The average precipitation is between 2000 mm to 4000 mm with the temperature ranging between 26°C to 32°C all over the region. The Malaysian climate has three attributes that is uniform temperature, high humidity and copious rainfall – round the year. The country is blessed that it is not directly influenced by the calamities like hurricanes, tornados, typhoon, volcanic eruptions and earthquakes but there are two significant water related problems causing adverse impact to this country that is excess water in terms of floods and water shortage in terms of droughts. Among these two significant causes, floods are considered to be the most notable natural disasters in Malaysia in terms of duration, frequency, area extent, affecting population and damaging the socio economic structure of the country.

There are a total of 189 river basins throughout Malaysia out of which 89 are in peninsular Malaysia, 78 in Sabah, and 22 in Sarawak. The main channels of these river basins are flowing directly to the South China Sea. Approximately, 85 of the river basins (45%) are marked prone to the regular flooding. The approximate estimated area inclined to flood disaster is 28900 km² or 9% of the total area of Malaysia which is affecting almost 4.82 million people, that counts nearly 22% of the total population of the country.

Historically, the Malaysian people are considered to be the riverine people as the early settlement grew on the river banks but still nearly 3.5 million people are reported to be residing on the flood plains which is undeniably frightening.

| Table 1. Natural disaster occurrence and impacts: Regional figures |
|---------------------------------------------------------------|

| The regional figures about the occurrence of natural disasters for the year 2014 and average 2004-2013 |
|--------------------------------------------------------------------------------------------------|
| No. of Natural Disasters | Africa | Americas | Asia | Europe | Oceania | Global |
|--------------------------|--------|----------|------|--------|---------|--------|
| Climatological 2014      | 5      | 9        | 5    | 1      | 1       | 21     |
| Average 2004-2013        | 13     | 9        | 5    | 4      | 1       | 32     |
| Geophysical 2014         | 4      | 8        | 17   | 2      | 1       | 32     |
| Average 2004-2013        | 2      | 6        | 21   | 2      | 2       | 33     |
| Hydrological 2014        | 24     | 31       | 65   | 29     | 4       | 153    |
| Average 2004-2013        | 45     | 38       | 83   | 20     | 5       | 192    |
| Meteorological 2014      | 6      | 28       | 57   | 22     | 5       | 118    |
| Average 2004-2013        | 9      | 38       | 47   | 28     | 6       | 127    |
| Total 2014               | 39     | 76       | 144  | 54     | 11      | 324    |
| Average 2004-2013        | 69     | 91       | 156  | 54     | 14      | 384    |
The regional figures about the people affected by natural disasters for the year 2014 and average 2004-2013

|                      | No. of Victims (Millions) | Africa | Americas | Asia | Europe | Oceania | Global |
|----------------------|---------------------------|--------|----------|------|--------|---------|--------|
|                     | Climatological 2014       | 6.61   | 29.73    | 31.73| 0.00   | 0.00    | 68.06  |
| Average 2004-2013    | 24.24                     | 1.84   | 26.83    | 0.12 | 0.00   | 0.00    | 53.03  |
| Geophysical 2014     | 0.01                      | 0.62   | 2.65     | 0.08 | 0.00   | 0.00    | 3.36   |
| Average 2004-2013    | 0.05                      | 0.94   | 7.51     | 0.02 | 0.00   | 0.07    | 8.59   |
| Hydrological 2014    | 0.98                      | 1.44   | 37.10    | 2.68 | 0.08   | 0.08    | 42.28  |
| Average 2004-2013    | 3.23                      | 4.48   | 86.07    | 0.32 | 0.08   | 0.08    | 94.19  |
| Meteorological 2014  | 0.13                      | 0.37   | 26.33    | 0.11 | 0.09   | 0.04    | 27.03  |
| Average 2004-2013    | 0.35                      | 2.56   | 40.30    | 0.19 | 0.04   | 0.04    | 43.43  |
| Total 2014           | 7.74                      | 32.16  | 97.80    | 2.87 | 0.17   | 0.19    | 140.74 |
| Average 2004-2013    | 27.86                     | 9.82   | 160.71   | 0.64 | 0.19   | 0.19    | 199.23 |

The regional figures about the damages caused by natural disasters for the year 2014 and average 2004-2013

|                      | Damages (2014 US $ Billions) | Africa | Americas | Asia | Europe | Oceania | Global |
|----------------------|-------------------------------|--------|----------|------|--------|---------|--------|
|                     | Climatological 2014           | 0.00   | 7.43     | 3.71 | 0.15   | 0.03    | 11.31  |
| Average 2004-2013   | 0.05                          | 4.40   | 1.12     | 1.74 | 0.29   | 0.70    | 7.60   |
| Geophysical 2014     | 0.00                          | 0.80   | 5.93     | 0.63 | 0.00   | 0.00    | 7.36   |
| Average 2004-2013   | 0.08                          | 4.48   | 40.93    | 2.00 | 2.62   | 50.12   |        |
| Hydrological 2014    | 0.12                          | 2.31   | 29.42    | 5.52 | 0.02   | 37.39   |        |
| Average 2004-2013   | 0.35                          | 5.11   | 19.32    | 5.19 | 1.32   | 31.32   |        |
| Meteorological 2014  | 0.39                          | 15.21  | 25.03    | 1.48 | 1.03   | 43.14   |        |
| Average 2004-2013   | 0.09                          | 53.98  | 13.87    | 4.52 | 1.03   | 73.48   |        |
| Total 2014           | 0.51                          | 25.76  | 64.08    | 7.77 | 1.08   | 99.20   |        |
| Average 2004-2013   | 0.58                          | 67.97  | 75.27    | 13.45| 5.26   | 162.53  |        |

Since 1920, Malaysia has experienced a series of floods. The recent monsoon flood from December 2014 and January 2015 are regarded as one of the most shattering floods to strike Malaysia. Officially, more than 100,000 flood victims were evacuated from their houses during these disastrous events. Similarly, the floods in December 2006 and January 2007 are also considered to be most damaging floods in the history of Malaysia. The flood strike as a result of two waves, the December 2006 (19th to 31st December) and January 2007 (12th to 17th January). The water level recorded during these floods reached 2.75 meters which is the highest level observed since 1950. The mortality rate recorded during these floods to strike Malaysia. Officially, more than 100,000 flood victims were evacuated from their houses during these disastrous events.

The Department of Irrigation and Drainage (DID), Malaysia has categorized floods into two categories that is flash floods and monsoon floods. Based on the hydrological perspective, the difference between the flash floods and monsoon floods rely on the time taken by the river flow to go back to its normal position. Floods can be predicted to a reasonable extent, with the exception of flash floods, whose scale and nature are often less certain. Flash floods are sudden and occur without any prior warning which surprise people during their daily routine and particularly hit people traveling. Whereas, monsoon floods are caused by the Northeast monsoon winds between the months of November to March and the Southwest monsoon winds between the months of May to September.

The major overflows Malaysia has experienced since 1920 were in the years of 1926, 1963, 1965, 1967, 1969, 1971, 1973, 1979, 1983, 1988, 1993, 1998, 2005, 2006 and 2007. The coastal plains and riverine areas of Malaysia are considered to be most extensive flood prone areas which are highly built up and densely populated. The state of Pahang, Terengganu and Kelantan in the East Coast of Malaysia gets severely affected by floods almost every year.
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Disasters, floods (06 events) were stated to occur most regularly followed by landslides (05 events), storms and epidemics (03 events each) and mudslides and tsunami (01 event each)\textsuperscript{1}.

Figure 3 shows the selected photos of the past flood events in Malaysia during the year 1926, 1967, 1971, 1995, 2004, 2006 and 2007\textsuperscript{21}. Table 2 shows the official flood loss estimates together with the number of deaths and people evacuated for the selected flood events in Malaysia from the year 1967 to 2012\textsuperscript{21,22} and Figure 4 shows the newspaper cuttings for the different flood events in Malaysia gathered from different sources\textsuperscript{21,22}.

Table 3 shows the rate of increase in the population of major urban centres located on the banks of major rivers in Peninsular Malaysia between 1957 and 1990. Other than Kuala kangsar (-5\% increase) located in Perak, there was observed an increase in the population almost in every centre with the highest increase of 513.3\% in K. Terrenganu\textsuperscript{23}. Therefore, there lies the responsibility on the Malaysian government to relocate these people to a safe place with all the basic facilities.

2.1 Causes and Effects of Floods in Malaysia

The majority of the Malaysians (those who are not affected by the floods) are not too concerned about floods. Despite the damage to the private and public properties, loss of

Table 2. Official flood loss estimates for selected flood events in Malaysia from the year 1967 to 2012\textsuperscript{13,21}

| Year   | Place                | Damage (RM Million, 1993 Prices) | Number of Deaths | People Evacuated |
|--------|----------------------|----------------------------------|------------------|------------------|
| 1967   | Kelantan R. Basin    | 199.3                            | 38               | 320,000          |
| 1967   | Perak R. Basin       | 154.5                            | 0                | 280,000          |
| 1967   | Terrengganu R. Basin | 40.2                             | 17               | 78,000           |
| 1971   | Pahang R. Basin      | 93.1                             | 24               | 153,000          |
| 1971   | Kuala Lumpur         | 84.7                             | 24               | NA               |
| 1979   | Peninsular Malaysia  | NA                               | 7                | 23,898           |
| 1982   | Peninsular Malaysia  | NA                               | 8                | 9,893            |
| 1983   | Peninsular Malaysia  | NA                               | 14               | 60,807           |
| 1984   | Batu Pahat R. Basin  | 20.3                             | 0                | 8,400            |
| 1986   | Peninsular Malaysia  | NA                               | 0                | 40,698           |
| 1988   | Peninsular Malaysia  | NA                               | 37               | 100,755          |
| 1988   | Kelantan R. Basin    | 33.0                             | 19               | 36,800           |
| 1988   | Sabah                | NA                               | 1                | NA               |
| 1991   | Peninsular Malaysia  | NA                               | 11               | NA               |
| 1992   | Peninsular Malaysia  | NA                               | 12               | NA               |
| 1993   | Peninsular Malaysia  | NA                               | 22               | 17,000           |
| 1995   | Peninsular Malaysia  | NA                               | 0                | 14,900           |
| 1996   | Sabah (June)         | NA                               | 1                | 9,000            |
| 1996   | Sabah (December)     | 130.0                            | 200              | 15,000           |
| Year | Place | Damage (RM Million) | Number of Deaths | People Evacuated |
|------|-------|----------------------|------------------|-----------------|
| 1997 | Kedah, Terengganu | NA | 5 | 5,321 |
| 1999 | Kedah, Pulau Pinang, Perak Utara | NA | 1 | 15,500 |
| 2000 | Terengganu, Kelantan | 7.1 | NA | NA |
| 2001 | Pahang, Johor | NA | 15 | 13,195 |
| 2002 | Kuala Lumpur | NA | NA | NA |
| 2003 | Kuala Lumpur, Pulau Pinang, Kedah | NA | 5 | 31,046 |
| 2004 | Kelantan, Terengganu, Pahang | NA | 17 | 17,080 |
| 2005 | Kedah, Perlis, Kelantan, Terengganu | 240.1 | 14 | 99,405 |
| 2006 | Johor, Negeri Sembilan, Melaka | NA | 15 | 107,000 |
| 2007 | Pahang, Kelantan, Johor, Kedah (Dec.) | 316.1 | 22 | 36,143 |
| 2007 | Kuala Lumpur (June) | NA | NA | NA |

| Year | Place | Damage (USD) | Number of Deaths | People Evacuated |
|------|-------|--------------|------------------|-----------------|
| December 2006 & January 2007 | Floods in Johor State | 489 million | 18 | NA |
| 2008 | Floods in Johor State | 21.19 Million | 28 | NA |
| 2010 | Floods in Kedah and Perlis | 8.48 Million | 4 | NA |
| 2011 & 2012 | La Nina in 2011 and 2012 (which brought floods) | NA | NA | NA |

life, drop in business and the inconvenience caused. There have been stated three major reasons that are responsible for the flood risks in Malaysia which includes human activities that has caused changes to the physical characteristics of the hydrological system, continued development of the areas that are prone to flooding and destruction of forests and hill slope development\(^{16,17}\).

In general, the north-east monsoon (October to March)\(^ {13}\), the south-west monsoon (May to September)\(^ {16}\), landslide and mudflow, inadequate drainage\(^ {11}\), soil erosion from land development into the river and etc. are considered accountable for the occurrence of floods in Malaysia\(^ {14}\).

Floods being a natural phenomenon have both positive and negative impacts. Floods are necessary for sustaining certain sector of biodiversity in the flood plains. It further replenishes the lands with nutrient rich soil which is good for the agricultural production and also recharges the ground water storage. On the other side, the negative impacts of floods are more prominent in the developed urban areas as it threatens lives, disrupt the economic and social activities and destroy properties. Further, the post flood recoveries can be costly to both the individuals and the Government\(^ {11}\).

### 2.2 Flood Mitigation Measures being used in Malaysia

To reduce the losses caused by the natural catastrophe like flooding the structural and non-structural approaches are usually undertaken\(^ {13}\). In flood management system, the structural measures refer to the choice of structural solutions that can mitigate the flood related issues. The instalment of these measures is beyond the capacity of individuals/public and can only be constructed by the government. The type of structural measure to be used to manage the flood flow is based on its specific function. The structural measures can only be the practical solution in some circumstances (e.g. land limitation) and if not regularly maintained then it can have disastrous consequences. Few examples of structural measures being used in Malaysia are shown in Figure 5\(^ {11}\).

The non-structural measures refer to programming, planning, setting policies, co-ordination, rising awareness,
strengthening the society to manage the impacts and threats of floods and warning and informing those at risk. These measures further aim at reducing physical and economical vulnerability and making the social structure of the community strong. These actions can be undertaken at individual, community and state level. The non-structural measures are considered more sustainable and more efficient solutions in long terms to the water-related problems. However, these measures should be enhanced, to minimize the vulnerability of human beings and goods exposed to flood risk. Few examples of non-structural measures being used in Malaysia are shown in Figure 6.

### Table 3. Rate of increase in the population of major urban centres located on the banks of major rivers in Peninsular Malaysia between 1957 and 1990

| Centre       | River (in parentheses) | 1957   | 1990   | % Increase |
|--------------|------------------------|--------|--------|------------|
| Kuala Lumpur| Kelang (in parenthesis)| 316,200| 919,600| 190.8      |
| Ipoh         | Kinta                  | 125,800| 293,849| 133.6      |
| Georgetown   | Pinang                 | 234,900| 248,241| 5.7        |
| Johor Bahru  | Johor                  | 75,100 | 246,395| 226.6      |
| Kelang       | Kelang                 | 75,600 | 192,080| 154.1      |
| K. Terrengau | Terrengau              | 29,400 | 180,296| 513.3      |
| Kota Bharu   | Kelantan               | 38,100 | 167,872| 340.6      |
| Kuantan      | Kuantan                | 23,100 | 131,547| 469.5      |
| Melaka       | Melaka                 | 69,900 | 87,494 | 25.2       |
| Alor Setar   | Kedah                  | 52,900 | 69,435 | 31.3       |
| Muar         | Muar                   | 39,100 | 65,151 | 66.6       |
| Batu Pahat   | Batu Pahat             | 40,000 | 64,727 | 61.8       |
| Keluang      | Mengkibol              | 31,200 | 50,315 | 61.3       |
| Teluk Intan  | Perak                  | 37,000 | 49,148 | 32.8       |
| Sungai Petani| Merbok                 | 22,900 | 45,343 | 98.0       |
| Dungun       | Dungun                 | 12,500 | 28,903 | 131.2      |
| Kulim        | Kulim                  | 17,600 | 26,817 | 52.4       |
| Kemaman/Cukai| Kemaman (NU)           | 15,952 | NA     | NA         |
| Kuala Kangsar| Perak                  | 15,300 | 14,539 | -5.0       |
| Mersing      | Mersing (NU)           | 13,888 | NA     | NA         |
| Pasir Mas    | Kelantan               | 13,402 | NA     | NA         |
| Tangkak      | Tangkak (NU)           | 13,251 | NA     | NA         |
| Kota Tinggi  | Johor (NU)             | 13,056 | NA     | NA         |
| Ampang       | Kelang (NU)            | 12,987 | NA     | NA         |
| Kuala Krai   | Kelantan (NU)          | 12,607 | NA     | NA         |

Figure 5. Few examples of structural measures.

Figure 6. Few examples of non-structural measures.

2.3 Malaysia Plan for Flood Mitigation Projects

To cope with flooding mishap, bulk of annual budget is kept for the flood disaster preparedness, relief operations, rehabilitation of post flood victims and public utilities. The economic development plan was first introduced by the government of Malaysia for the welfare of its citizens. Keeping in view the prolonged rainfall and the regular flood events endangering the property and life of the citizens, the government of Malaysia decided to allocate funds from the national budget for the flood mitigation measures in every of its Malaysia plan (five-year plan). Figure 7 shows the allocated amount by the Malaysian government for flood mitigation measures under this proposal. Allocation of such an amount clearly shows that the Malaysian government is well familiar with the needs of the country to avoid the damages caused by floods.
2.4 Flood Warning and Forecasting Services in Malaysia

Flooding is inevitable, but the hazards associated to it can be reduced through effective management and planning. For successful mitigation of flood damage, proper flood forecasting and warning is mandatory. Its potency relies on the level of correct response and effective preparedness. Therefore, it is the responsibility of the concerned government authorities to provide reliable and timely flood warnings.

The previous records have shown that the first flood warning was provided during the flood events in the year 1925 when the floods occurred along the Klang river in Selangor, Kinta River in Perak and Bernam River in Selangor and Perak boundary, Malaysia.

The National Disaster Relief Committee was established in 1972 after the disastrous flood of 1971, headed by the Deputy Prime Minister of Malaysia in the National Security Council of Prime Minister Department. The tasks given to this committee were to co-ordinate flood relief operations at National, State and District level; prevent loss of human lives and reduce flood damages.

The committee consists of various cabinet ministers, such as the Minister of National Resources and Environment, the Minister of Social Welfare, the Minister of Finance, the Minister of Science, Technology and Innovation, senior government officials such as Government’s Chief Secretary, the Army General and the concerned government agencies such as Department of Irrigation and Drainage (DID), Malaysian Meteorological Department (MMD), Malaysia Centre of Remote Sensing (MACRES), Social Welfare Department, Fire and Rescue Department, and Police Department. However, the additional responsibility of flood mitigation was assigned to DID from 1972 onwards with the following tasks:

- To execute Flood Mitigation Projects,
- To carry out river basin studies and
- Implementation of flood warning and forecasting services.
- The DID follows the mentioned operating procedures under the flood relief mechanism as described below and shown in Figure 8.
- The relevant flood control centres are advised by the DID to activate their flood relief mechanism when the river stage of flood warning station reaches the “alert level”.
- The flood forecast operation is then carried out by the respective state DID office using real time telemetric data and river forecasting computer models.

If at any forecasting point, the river water level exceeds the “critical level”, the forecast is then transferred to the flood operation centres and the concerned government agencies such as the National Security Division (BKN) and the national and state control centres for flood relief and operations.

During the flood event, the officers in charge of the government agencies like DID, MMD, BKN, Police and Army receives a Short Message System (SMS) alert. Further, the info banjir webpage provides the updated real time information of river water levels and rainfall which is published online at www.infobanjir.water.gov.my. The online webpage is accessible to the public and the government officials that enables effective early flood warning through internet at any time and any place.

3. Research Gap

This paper has collected, classified, arranged and stored all the scattered information related to floods in Malaysia into one record. A systematic approach was followed to conclude the study following disasters Worldwide, the

![Figure 8. Water level classification and flood warning centre (DID)](image-url)
most affected continent, mortalities by disaster type, floods history in Malaysia, causes and effects of floods, the allocation of budget for floods mitigation under the Malaysia Plan and the responsibilities of government agencies during the flooding conditions.

Despite the fact that most of flood deaths have occurred in developing countries, majority of the studies are limited to the United States, with a few in Europe and Australia. Experiences from past floods, demonstrate that a common hazard which causes risk of death or serious injury to the people is due to the instability of vehicles in floodwaters. Therefore, the stability of vehicles during urban flood events has aroused recent interest from the Environmental Agency in the United Kingdom and other flood management authorities around the World.

Drowning is considered to be the major cause of deaths during floods and nearly 2/3 of the fatalities that occur during floods are due to drowning (majority of which are reported in vehicle). Further, it has been stated that one of the factor that contributes to the flood fatality occurrences is human behaviour as people tend to intentionally drive through the flooded areas by “neglecting risks such as underestimating warnings and ignoring traffic safety barriers” and get swept away due to the buoyancy force or stuck in the flood water.

Except for certain distinctions, specifically the language used, the Malaysian road signs are nearly similar to those in the World. Perhaps, it is still believed that there is a need of an Integrated Smart Alarm System that can be used in the flood prone regions to minimize the vehicle related fatalities.

4. Conclusions

In summary, the purpose of this paper was to highlight the disaster type which has severely affected the continent Asia, particularly Malaysia. While focusing the Malaysian region, the study further reviewed the history of major floods in different years by portraying it in the form of photographs and newspaper cuttings. The consequences and effects of floods were also discussed and the flood mitigation measures being used in Malaysia were briefly discussed. Further, the paper reviews the budget allocation for the flood mitigation projects by the Malaysian government under the Malaysia Plan. Lastly, it defines the responsibility of government agencies responsible for the flood mitigation projects and point out the research gap, observed while conducting the literature survey.

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