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DRIVERS' ADAPTIVE TRAVEL BEHAVIORS TOWARDS GREEN TRANSPORTATION DEVELOPMENT: A CRITICAL REVIEW

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Abstract: *The transportation professionals integrated the concept Green in various dimensions of transportation, such as, green vehicle, green highway. The current study has established a new dimension to green transportation, which is called Green Driver as whom substantially contributes to less emission and fuel consumption, and higher-safety. The research established the driver's Green Adaptive Travel Behaviors (GATB), in particular, that is referred to voluntary personal and lifestyle behaviors on less energy consumption and emission. The methodology was designed into two phases. Phase one was to investigate driver's GATBs through systematic literature review process and content analysis method. The second phase was to verify greenery value impact (GVI) of the finalized list of drivers' GATBs through an expert input study and Grounded Group Decision Making (GGDM) method. Total twenty six (26) GATB factors have been determined. Amongst, the factor 'F27- Dangerous overtaking' has received the highest value (97%) followed with 'F3- Slow once realizing bike lanes for cyclist crossing' (91%). In contrast, 'F4- Realize visual Obstacles to manage the speed' and 'F21- Brake with smooth deceleration' has received the lowest value (77%) among other factors. Two of the initial factors;'F5-Use traffic calming devices' (55%), and 'F24- Change highest possible gear' (69%) could not reach the 70% saturation; hence, they have been dropped from the list of GATB factors. Indeed, the GATB efforts are not limited to technology and practice; but also can include education and enforcement to driving regulations in order to interconnect driver, technology, environment, and vehicle. The research concluded with an innovative technique used as the decision support tool to evaluate the greenery grade of any individual driver on committing to less emission, less fuel consumption, and higher safety in traveling. As future study, the Green driver behaviour index assessment model will be developed based on this study outputs.*

Key words: *driver travel behavior, adaptive behavior, green transportation, transportation emissions, fuel saving, safety.*

1. Introduction

The number of vehicles is anticipated to triple by the year 2050 worldwide (World Hydrogen Energy, 2010), which causes traffic pollution in all major cities in the world (Saboohi and Farzaneh, 2009). On the other hand, world population is rapidly growing. Shi (2003) states any 1% of population growth may cause 1.42% increasing in CO_2 emission. This made the transportation sector as the major contributor of double growth of CO_2 in previous decades, and 70% of Greenhouse Gas (GHG) emissions (due to fossil fuel burning).

The reduction of hazardous gases is an ultimate goal in green transportation (Lee et al., 2013; Wasiak, et al., 2014; International Energy Agency-IEA, 2011). Although tightened government regulations and improved technologies have reduced the levels of emitted gases, pollution potential of environmental emission is still high (McKinnon, 2010, McKinnon et al., 2010). In this regards, transportation engineers and planners have imposed emission reduction techniques; such as, signalization of intersections and speed ramps, and designation of speed limit area. In road network, lane configuration and signal timing play critical roles in minimizing the emissions level. It is evidenced that individual lane set configuration affects traffic flow and emissions level (Bing et al., 2014). Road intersection designs have become significant since then. Transportation researchers and traffic engineers have investigated diverse associations between signalized and non-signalized intersections and roundabouts to the elevated CO_2 level. For instance, Hydén and Várhelyi (2000) have carried out an observation before and after roundabout installation at non-signalized and regular intersections. They found out at a previously signalized intersection (after roundabout replacement) CO is decreased by 29% and NO_x is decreased by 21%. On the other hand, CO and NO_x are increased by 6% and 4% respectively at previously non-signalized intersection (after roundabout installation). Installation of road humps for speed restrictions seems to amplify the effect of emissions in comparison to a smooth non-calmed road; CO_2 (90%), CO (117%), NO_x (195%) and Hydrocarbon (HC) (148%) (Daha et al., 2005). At present, the rate of road transportation emissions is still high and prominent. Subsequently, the growing concern on CO_2 and other hazardous emissions and energy security has led to many policy declarations and strategies over the past decades; such as LCFS (Low Carbon Fuel Standard), and CAFE (Corporate Average Fuel Economy) standards. For example, CAFE standard requires all vehicles produced from 2012-2016 to "improve fleet-wide fuel economy and reduce fleet-wide GHG emissions by approximately 5% each year" (U.S. Department of Energy, 2012).

On the other hand, drivers do not simply follow traffic safety rules, and thus, their travel behavior is significantly reducing the safety margins, while increasing the likelihood of road fatalities and injuries (Iversen and Rundmo, 2002). Safe driving practices mainly emphasizes on the advanced safety features of vehicles, economical driving practices, and traffic safety regulations and enforcements; however, the driver's cognition and attitude on enhancing safe driving is a missing dimension in the green transportation. Regarding major challenges in driver travel behavior studies (i.e. less emission, less fuel consumption, and higher-safety), the current study has established a new dimension to green transportation, which is called 'green driver'. A green driver is defined as a driver who substantially contributes to less emission and fuel consumption, and higher-safety. This study presents the comprehensive description and indicators of the green driver concept.

2. Problem Statement

International Energy Agency (IEA, 2011) reports transportation accounts for almost 70% of global energy consumption, and is responsible for 23% of all energy-related CO_2 emissions. In this regards, IEA (2011) instructed that "the countries need to reduce the overall CO_2 emissions by at least 40% between 2005 and 2020". Transportation CO_2 emission trend in the global perspective depends on nation's mobility efficiency, road network efficiency, and traffic volume management. Vehicle CO_2 emission trend in UK was recorded as 25% (EUROSTAT, 2012), while in Portugal, US, Japan, China, India, and Malaysia were estimated as 20% (EUROSTAT, 2012), 28% (EPA, 2015), 19% (Matsumoto and Tsurudome, 2014), 23% (IEA, 2011; Yin, et al., 2015), 28.33% (N.P., 2013), and 22.9% (Economics, 2013), respectively. According to Energy Technology Perspectives (2012), transportation (21%), after the power-generation sector (42%), is the world predominant contributor in CO_2 emission reduction (in the 2°C scenario) followed by industry (18%), and Building (12%) (see Figure 1).

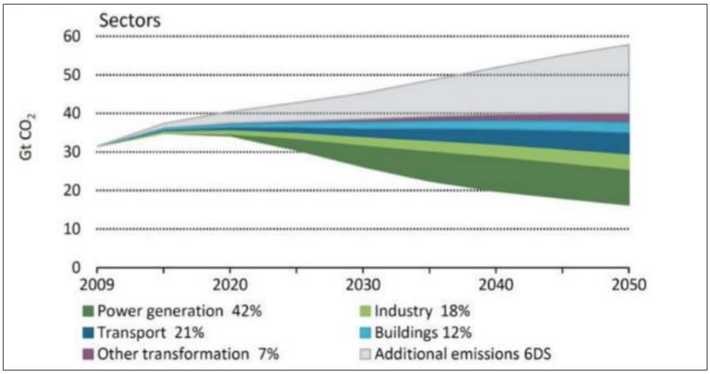

Fig. 1. Global contributions to CO2 emissions (GtCO2) reduction in the 2°C scenario by sector
Source: Energy Technology Perspectives (2012).

According to the International Energy Agency (IEA, 2011), transportation sector accounts approximately half of the global energy consumption. As can be seen in Figure 2, oil is the main source of fuel in transportation, which has an ever-increasing trend in comparison with other energy sources (i.e. coal, natural gas, Hydro, Nuclear, and other renewables) (British Petroleum-Statistical Review of World Energy, 2013). Figure 3 shows the projection of world fuel consumption in the period 1900 to 2050 (The cultural Economist Data from British Petroleum, 2013). This figure reveals a faster trend in world fuel consumption per capita (based on MTOE - Million tones of Oil Equivalent data) than population growth (based on UN – United Nations Data). Fuel consumption trend in the global transportation perspective depends on the development of a nation, complexity of road network, mobility efficiency, and traffic volume intensity. UK consumes 33% of fuel energy (EUROSTAT, 2012; Żochowska, 2014), while in Portugal, United States, China, India, and Malaysia have consumed by 40% (EUROSTAT, 2012), 28% (EIA, 2013), 19% (IEA, 2011), 16.9% (TERI, 2002), and 25.5% (Devaraj et al., 2013), respectively.

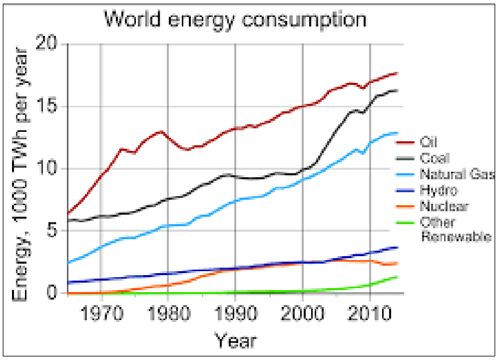

Fig. 2. World Energy Consumption
Source: Adapted from BP-Statistical Review of World Energy, London, 2013.

World Health Organization (WHO, 2004) reports that "road traffic injuries caused an estimated 1.24 million deaths worldwide in the year 2010" which cost countries 1–3% of their GDP (Gross Domestic Product). In 2013, 20-50 million were suffered from various kinds of traffic injuries (WHO, 2013). In Europe, added 25,845 people were killed in 2014 compared to the previous years due to road collisions (ETSC, 2015). According to World Health Organization (WHO, 2013) "half of the world's road traffic deaths occur among motorcyclists (23%), pedestrians (22%) and cyclists (5%) with 31% of deaths among car occupants and the remaining 19% among unspecified road users". These figures are almost similar in different regions in the world (see Figure 4). By 2030, road traffic injuries will be recognized as the leading cause of death by injury which is predicted as the 5th leading cause of death in the world (WHO, 2013).

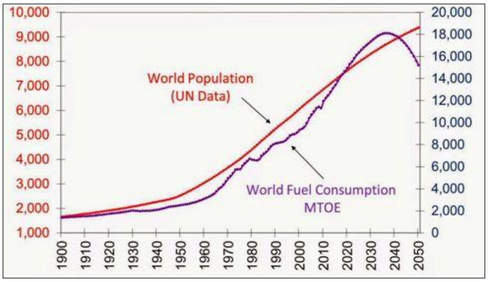

Fig. 3: World Fuel Consumption and Population, 1900-2050
Source: Adapted from The cultural Economist Data from British Petroleum.

Many studies express that urban, social, and economic factors make changes in driver's behavior (Bamberg, 2006; Graham Rowe et al., 2011; Saniul Alam and McNabola, 2014), but those studies were not sufficiently successful to investigate details of the association between driver's behavior to emission and fuel consumption (Doppelt and Markowitz, 2009). There are evidences it is possible to reduce transportation emission and fuel consumption by driver travel behavior; however, "there does not appear to be substantial research on how specific behavioral changes can lead to measurable reductions in emissions" (Doppelt and Markowitz, 2009). According to Glanz et al. (2008), the modifiable factors (i.e. drivers' beliefs, attitudes, preferences, and social and physical determinants) are focus of behavioral change studies.The modifiable factors are divided to individual level, social level, and urban level (Rimer, 2008; Titze et al., 2010). Driver's self-motivation composed of the individual level is required to cater the green travel behavior aspect. Followed by driver's concern on society and people in a social level (Titze et al. 2010, Phongsavan, et al., 2007, Cleland et al. 2008).

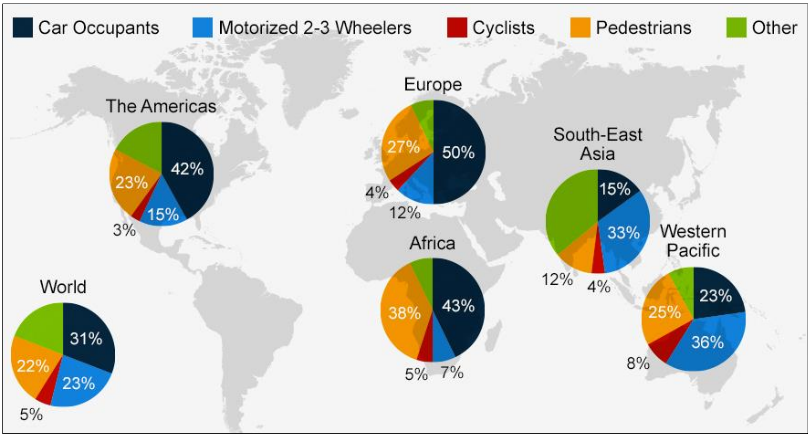

Fig. 4. Road traffic deaths by type of road user by region in 2010
Source: Adopted from WHO (2010).

Finally, the urban level is referred to the contribution of physical and environmental qualities of urban transportation system and networking to green diving (Lamit et al., 2013a; Lamit et al., 2013b). In fact, urban level plays significant role in performing green driving as compared to other two levels. Transportation engineers have imposed several strategies and techniques to enhance green transportation in the urban level. For example, Ericsson (2001) indicates that availability of the traffic lights in various network types affects fuel consumption. According to Table 1, in a local network with dense traffic lights and 30-50km/h speed-limit has exhibits 0.14L/km fuel consumption; while by installing traffic calming device (exclude traffic lights) can reduce the fuel consumption to 0.10-0.12L/km in main road network. In contrast, the central business districts show higher fuel consumption with denser traffic lights installation (but without calming device) within the range of 0.12-0.16L/km. Finally, for a road network with low impact traffic lights consumes less than 0.1L/km fuel.

On the other hand, in urban level, few green urban assessment tools have been developed with the aim of green transportation development; named, the LEED-ND (The Leadership in Energy and Environmental Design for Neighborhood Development) (USGBC, 2008), and the Malaysia Green Neighborhood Index-GNI. The LEED-ND focuses on green transportation through smart transportation linkage and location. The LEED-ND promotes the green transportation based on reduced vehicle miles travelled (VMT), and accessibility to jobs and services by foot or public transit. The GNI imposed the policies and strategies towards green transportation through promoting transit-oriented development, using cleaner fuels, and smart growth. Indeed, these green urban assessment tools have neglected the green driver factor as a very critical factor in successful green transportation development.

Table 1. The association between traffic calming and fuel consumption in different transportation network type in a neighborhood

Network type	Condition	Fuel consumption
Local network	without traffic calming device	0.14L/km
Main road network	with traffic calming device	0.10-0.12L/km
Central business district	with traffic calming device	0.12-0.16L/km

Source: Adopted from Ericsson (2001).

Moreover, previous studies have investigated the travel driver behavior from the perspectives of beliefs, reaction skills, and capabilities; however, these studies have not yet investigated the 'adaptive' behaviors which can considerably contribute in driver's behaviors changes towards reduction of travel emission and fuel consumption, and simultaneously, increment of safety. The adaptive behavior is referred to; (1) Technological and personal adaptation (e.g. personal, environmental, technological, or cultural), (2) Physiological adaptation (e.g. genetic adaptation or acclimatization), and (3) Psychological adaptation (e.g. habituation or expectation) (de Dear; 2007; de Dear and Brager, 1997). Therefore, as transportation engineers and planners became more conversant on environmental issues, there is a crucial need to promote and practice of green driver concept, especially in urban roads and streets. The green driver concept may gain high interest among car manufacturers and car designers too, who can improve the existing vehicle technologies towards more fuel saving, less tailpipe emissions, and safety (see Figure 6).

3. Identification of Driver's Adaptive Travel Behaviors

3.1. General assumption

According to the issues and problems discussed, it is necessary to investigate the driver's travel adaptive behavioral modification to green interventions. This enables transportation and urban managers to achieve low-emission and safe cities. Essentially, it is to obtain the best green solution from the trade-off challenges between driver's travel behavior and his/her adaptive behavior, and his/her travel energy savings skills and perception. The current research aimed to identify the comprehensive list of driver's green adaptive travel behavior (GATB) factors, and determine the greenery value impact (GVI) of each factor to green driving. In fact, the ultimate goal of this long-term research is to develop the 'Green Driver Behaviour Index Assessment Model' by involving the GATB factors. This index assessment model will be used to measure the GVI of driver's behaviours on higher-safety and lower-emission and fuel consumption.

The methodology was designed into two phases. Phase one was to investigate driver's adaptive travel behaviors through systematic literature review process and content analysis method. The second phase was to verify greenery value impact (GVI) of the final list of drivers' green adaptive travel behaviors through an expert input study and Grounded Group Decision Making (GGDM) method. The following sections present each phase, respectively.

3.2. Systematic Screening of the Driver's Adaptive Travel Behavior Literatures

In phase one, the research organized the systematic literature review process to investigate driver's adaptive travel behaviors from the existing literatures. In comparison with traditional narrative reviews, this systematic process has prominent by adopting a replicable, scientific, transparent and detailed process (Cook et al., 1997; Cook et al., 1997; Wolf et al., 2001). Undertaking systematic review process is regarded as a fundamental scientific stage in investigation of factors to develop the Green Driver Behaviour Index Assessment Model.

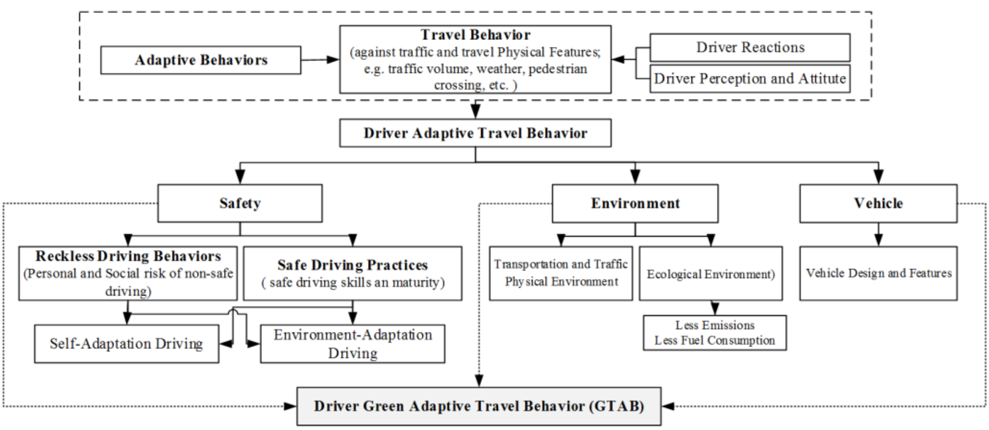

Fig. 6. The conceptual framework of driver's green adaptive travel behaviors

To conduct the process, combinations of keywords (i.e. searching codes) have been surfed via Internet searching. The keywords undertaken were; Driver Travel behavior, travel behavior modifications, travel behavior changes, low-energy city, sustainable urban development, and green urban development. The search was conducted on available online databases from which a set of published articles, books, reports, and standards were identified.

3.3. Identification of Driver's Adaptive Travel Behaviors in association with Safety, Environment, and Vehicle Emission

Referring to green driver concept (Figure 6), safety, environment, and vehicle dimensions can contribute to green transportation development. Failure combination of interactions between road safety, motor vehicles, and environment can lead to higher emissions and fuel consumption, and also, road crashes, injuries and death (European Commission, 2004; Hermans et al., 2008; WHO, 2004). The following presents the driver's adaptive travel behaviors involved in each green driver dimensions as; i) driver's adaptive travel behaviors for personal and physical safety, ii) driver's adaptive travel behaviors for environment protection, and iii) driver's adaptive travel behaviors for vehicles functional and operational characteristics. The following explores each green driver dimensions, respectively. The study has identified totally twenty-eight (28) driver's adaptive travel behavior factors in phase one (see Table 3). The definition of each factor has been provided in Table 3, as well.

i) Driver's adaptive travel behaviors for personal and physical safety:

Advanced safety features like lane keeping warning system, adaptive cruise control, frontal collision detection, and drive camera are some of the intelligent features that have been adopted by most automakers like Honda, BMW, Mercedes Benz, Hyundai-Kia, Toyota, Mazda, and Ford. These features not only facilitate driving and aid drivers in collisions, but also improve vehicle fuel economy and safety of the drivers. These features are also important to maintain efficient speed and braking activities of a car. Thus, they can promote a safer and economic driving. For example, the ADAS (Advanced Driver Assistance Systems) is a vehicle control system that uses environmental sensors (e.g. radar, laser, and vision) to improve driving comfort and traffic safety by assisting the driver in recognizing and reacting to potentially dangerous traffic situations (Gietelink and Ploeg, 2006). While, drive camera was designed to capture audio and video inside and outside of vehicle when triggered by unusual motions; such as, hard braking, swerving or a collision (DriveCam, 2009). Frontal collision detection is a sensor located at front of a car to monitor the distance and relative speed of a vehicle ahead (Transport Canada, 2011).

Driver's safety motives are influenced by age, gender, driving experience and ability to control driving including driver's determination to drive at safe distance and safe speed. Corresponds to that, driving feedback is notably embedded into the safety motives attributes as to improve safety while driving (OECD, 2006; Gregersen, 1996). An aggressive driving style records fluctuation of high speed within 70-80km/h, throttle behavior and air fuel ratio in between 430-480s (Alessandrini ey al., 2006). On the other hand, driver's cognitive skill plays an important role in safe driving because drivers must have the ability to control a vehicle. Therefore, the factors affecting driver's consciousness (e.g. seizures, syncope, hypoglycemia and sleepiness), perception (e.g. visual acuity and field of vision), mental functioning (e.g. dementia), neuromuscular and musculoskeletal function (e.g. adequate manipulation of vehicle controls), and self and impulse control may limit safe driving (Galski et al., 1993).

Apart from aforementioned features, improving driving practice could also enhance safe driving. The safe driving practice can be enhanced through vehicle speed control (WHO, 2004), constant acceleration while overtaking, car following, or lane changing (Dey et al., 2006), applying progressive and smooth braking (Farlam, 2012), and avoiding gear snatching (IAM, 2016).

ii) Driver's adaptive travel behaviors for environment protection:

Road design and road environmental-oriented factors are also vital to enhance safe driving practice. Proper design of intersections and crossings (WHO, 2004, West Windsor Bicycle and Pedestrian Alliance, 2002)can reduce the severity of potential conflicts between motor vehicles, buses, trucks, bicycles, pedestrians, and facilities; while facilitating the convenience, ease, and comfort of drivers for safe driving (AASHTO, 2011). Hence, identification of any actual or potential safety-problematic intersection is essentially needed to reduce the accident and fatality risks among road users (MMUCC, 2012).

iii) Driver's adaptive travel behaviors for vehicle functional and operational characteristics:

Vehicle design factors (including; lighting, braking, speed level, interior, maintenance), and environmental quality factors (including; traffic congestion, travelling distance) are also crucial to ensure safe driving among road users (TxDOT, 2014; van Schoor et al., 2001; Brundell-Freij and Ericsson, 2005).

Vehicle operational characteristic are categorized into seven sub-features; included, types of fuel, engine, horsepower, vehicle transmission, weight, rolling resistance, vehicle routing, and maintenance. Types of engine and horsepower are important to distinguish the performance level and specific fuel consumption of a car. For example, three (3) Honda Civic versions were tested (Euro IV 2000, the IMA, and Euro IV Hybrid); The measured average consumptions shows that the Euro IV Hybrid has the lowest fuel consumption (8.23 L/100 km), following by IMA (9.95 L/100 km) and Euro IV 2000 (12.66 L/100 km), respectively. Such differences show how hybrid vehicles tend to consume less than conventional vehicles (Alessandrini et al., 2006).

Fuel consumption on lower speed (i.e. 50km/h) results in 25% fuel economy compared to the higher speed (i.e. 120km/h) results in 9% fuel economy (Lee et al., 2012). It is presumed that different speeds affect fuel consumption and CO_2 emission. A study has been conducted on association between speed and acceleration and emission level, for gasoline and diesel types of fuels in France, Germany and UK. Table 2 presents the results as reported by Joumard et al. (1995). According to Table 2, tripling the speed cause lower fuel consumption; however, the CO_2 emission is consistent.

Indeed, lower engine performance, lower weight, small engine size and automatic engine stop had emitted almost negligible emissions and lower fuel consumptions (Van Mierlo, Maggetto, Van de Burgwal, & Gense, 2004). As the weight of a vehicle is directly proportional to its fuel economy, lighter cars are significantly more fuel efficient than their heavier counterparts. If a vehicle is made 10% lighter, fuel efficiency improves by 5-8% (EPA, 2001, Van den Brink and Van Wee, 2001). Different transmission affects also fuel consumption. For example, manual drive car allows driver to control gear changing which is slightly efficient compared to an auto drive car.

It was found that air-conditioning operation increased the fuel consumption by 90% maximum compared with the operation without air-conditioning during the idling condition. During idle engine, 50Nm was exerted with air conditioner and zero torque without air conditioner. At 2000rev/min engine speed (100km/h speed), 140Nm torque was exerted with air conditioner and 120Nm torque without air conditioner. Air conditioner usage may require more energy to travel; thus, more fuel is consumed which equals to 82.7 g/km (26%). Due to the air conditioning activity, an extra CO_2 emission is found about 2.4-18 g/km at 13 °C (1.5-7%), owing to demisting activity. Demisting activity here refers to the removal of mist or vapors results from an engine evaporation (Weilenmann et al., 2005). Among the A/C system components, the most important component affecting the fuel consumption is the compressor, which caused a fuel consumption increase of 77–89%. The contributions in order after this component are as follows: from the blower, 6–12%; from the cooling fan, 4–10%; from the clutch, 0.7–2% (Lee et al., 2012). Fischer (1995) has estimated that by using the 13.6kg weight of air-conditioner within 16,400km/year, the amount of gasoline per year would be 12.7L/year while, the CO_2 emission for transporting the system and its lifetime emission are 29.5kg CO_2/year and 325kg CO_2/year, respectively.

Table 2. The association between speed and acceleration and emission eruption for different types of fuels

Speed	**Fuel type and amount**	**CO_2 emission**
Lower speed (15km/h)	Gasoline, ≈100g/km	≈200g/km
	Diesel, 50-100g/km	≈200g/km
Higher speed (45km/h)	Gasoline, 50-75g/km	≈200g/km
	Diesel, 50g/km	≈200g/km

Source: adopted from Joumard et al. (1995).

Table 3. The driver's adaptive travel behavior factors, definitions and clustering

Cluster	Driver Behaviors	Definition and citation
E.	**F1**- Remove unnecessary misalliances from car	"Maximum weight a vehicle is designed to carry including the net weight of the vehicle with accessories, plus the weight of passengers, fuel, and cargo" (Infrastructure, 2015)
S.	**F2-** Slow speed in and near to pedestrian crossing	"Any crossing established for the use of pedestrians on a road, subway or bridge indicated by traffic signs, road markings or otherwise" (RULES, ROAD TRAFFIC, 1992) Three main types of pedestrian crossings such as, zebra crossing (which is uncontrolled), traffic light controlled crossings (which exists at the traffic lights or under direct control of pedestrian i.e. pelican, puffin and toucan crossings), and supervised crossings (which normally controlled by police officer or traffic/school wardens) (Jenkins, 2015)
S.	**F3**-Slow once realizing bike lanes for cyclist crossing	"… most drivers appear to recognise that ideally they should give consideration to the cyclist, slowing down if necessary and waiting until it is safe to pass the cyclist or until sufficient space is available to give the cyclist adequate clearance" (Basford et al., 2002)
S.	**F4-** Realize visual Obstacles to manage the speed	"Cognitive impairment is defined as decline in at least one of the following areas: short-term memory, attention, orientation, judgment and problem-solving skills, and visual-spatial skills" (Chang et al., 1999) Observation is key to safe driving – but it is not good enough just to keep looking around; you need to understand, interpret, and priorities what you are seeing, and then effectively plan how to deal with it (Raedt et al., 2000)
E.	**F5-** Use Traffic Calming Devices	"The combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behaviour and improve conditions for non-motorized street users" (Lockwood, 1997) " Set of street designs and traffic rules that slow and reduce traffic while encouraging walkers and cyclists to share the street" (Alternatives, 2015)
E.	**F6**- Use first available public parking	"…the probability to find the available space still free when a vehicle finally reaches the spot". (Verroios et al., 2011). "As the vehicle navigates, it continuously receives reports about available spots close to the area the driver intends to park from oncoming traffic". (Verroios et al., 2011)
E.	**F7-** Using first available on-street parking	"As the vehicle navigates, it continuously receives reports about available spots close to the area the driver intends to park from oncoming traffic". (Verroios et al., 2011). "…it results in a reduction of 15% in total travel time". (Moini et al., 2013)
S.	**F8**- Keep a safe gap to avoid sharp breaking	Motives for driving includes to not driving by choosing another transportation means or to choose a particular driving speed or following distance when driving (Gregersen, 1996). "It is an advanced cruise control system that can also keep a set distance behind another vehicle. A sensor in front monitors the distance and relative speed of a vehicle ahead. The ACC system then adjusts vehicle speed to maintain a driver-selected cruising speed and minimum following distance. If the ACC system detects that the vehicle in front is slowing quickly or if another vehicle cuts in front from another lane, the system automatically applies limited braking and may alert the driver with a warning light or sound" (Transport Canada, 2011)
E.	**F9-** Use satellite navigation systems for short path to destination	"Designing routes for delivery vehicles (of known capacities) which are to operate from a single depot to supply a set of customers with known locations and known demands for a certain commodity. Routes for the vehicles are designed to minimize some objective such as the total distance travelled" (Beasley, 1983) "the lane keeping system is designed to help keep the vehicle driving in the correct lane, even if the driver is distracted or becoming drowsy" (Kirchner, 2014) "Lane Keeping Assist technology is designed to alert the driver when the system detects that the vehicle is about to deviate from a traffic lane. The system can also work in conjunction with the Radar Cruise Control system to help the driver steer and keep the vehicle on course" (Toyota, 2015)

Cluster	Driver Behaviors	Definition and citation
S.	**F10**-Slow once realizing sidewalk	"Install detectable warnings to identify the transition between the sidewalk and the street". (US Department of Transportation, 2016) "Chokers are midblock curb extensions that narrow the street by expanding the sidewalk or adding a planting strip and often are installed at midblock crossings". (US Department of Transportation, 2016)
S.	**F11-** Avoid to non-necessary overtaking	"The act of one vehicle going past another slower moving vehicle, travelling in the same direction, on a road" (Blanco, 2014) "Acceleration characteristics in standstill condition, during overtaking, lane-changing, car-following and under free-flow traffic condition are important" (Dey et al., 2006)
S.	**F12-** Keep a safe gap to avoid stop-and-go driving	"'Progressive braking describes the skill of spreading your braking for smoothness and safety. Progressive braking starts with gentle pressure on the brake which is gradually increased to reduce speed; you then gently release the pressure as you reach your target speed (or just before the car stops)." (Farlam, 2012) "Control the movement of a vehicle, causing it to slow and stop, and control its direction" (AAOS and Beck, 2011)
S. & E.	**F13-** Plan ahead to avoid stop-and-go driving	"Prompts the driver not only to recognize and correct possible shortcomings, but also to plan ahead for inevitable effects of aging" (MVA, 2015)
E.	**F14-** Close the windows once using AC (air-condition)	"…. driving with the windows down has a significant negative effect on the fuel efficiency -- more than using the vehicle's air conditioner"(DeHaan, 2011) "…when the windows were down, the efficiency was reduced by 20 percent,…"(DeHaan, 2011)
V.&E.	**F15-** Use smart speed adaptation system	"A forward collision warning system, also known as a front crash prevention system or a collision mitigation system, scans the road ahead using radar beams, laser beams, cameras, or a combination of these technologies. When the system determines that the vehicle is closing on an object at an unsafe speed – be it another vehicle, a cyclist, or a pedestrian – it alerts the driver and either readies the braking system for full braking power, or automatically brakes the car" (Wardlaw, 2014)
V.	**F16-** Chang car oil by specific traveled millage	"Is an integral part of the operation for the well being of any mechanical objects and requires manufacturer services to be adhered to, in order to ensure reliability" (Hendriks, 2015)
E.	**F17**-Adjust air-condition operative hours	"The prevailing atmospheric conditions that existed at the time of the crash" (MMUCC, 2012)
E.	**F18-** Adjust furniture materials compatible with region climate	"Automotive design is the profession involved in the development of the appearance, and to some extent the ergonomics, of motor vehicles or more specifically road vehicles. It commonly refers to automobiles but also refers to motorcycles, trucks, buses, coaches, and vans. Automotive design in this context is primarily concerned with developing the visual appearance or aesthetics of the vehicle, though it is also involved in the creation of the product concept" (The Art Career Project, 2014)
E. & S.	**F19-** Use moderate speeds and keep it steady	"An ADAS is a vehicle control system that uses environment sensors (e.g. radar, laser, vision) to improve driving comfort and traffic safety by assisting the driver in recognizing and reacting to potentially dangerous traffic situations." (Gietelink et al., 2006)
E.	**F20-** Use the engine brake instead of brake pedal	"'Progressive braking describes the skill of spreading your braking for smoothness and safety. Progressive braking starts with gentle pressure on the brake which is gradually increased to reduce speed; you then gently release the pressure as you reach your target speed (or just before the car stops)." (Farlam, 2012)
E.	**F21-** Brake with smooth deceleration	"Progressive braking is essentially variable braking instead of constant braking. It should start slight, increase with pressure and finish light. Progressive braking is a safe driving technique, which allows for other drivers to react to your actions, prevents locked wheels, prevents the car from skidding, reduces wear on the brakes, tires, suspension and other mechanical parts, saves on fuel and more comfortable for passengers" (Driving Test Tips, 2016)

Cluster	Driver Behaviors	Definition and citation
E.	**F22-** Open or close window(s) using smart system	"An ADAS is a vehicle control system that uses environment sensors (e.g. radar, laser, vision) to improve driving comfort and traffic safety by assisting the driver in recognizing and reacting to potentially dangerous traffic situations." (Gietelink et al., 2006)
E.	**F23-** Switch off the lamps / lights once not needed	"Turning off the car at a red light saves fuel, as long as the car is properly warmed up. This is especially true if you wait a very long time" (Kolasa, 2016)
E.	**F24-** Change highest possible and eligible gear	"snatching" at gears is a common driver fault, causing an abrupt gear change and a less than comfortable ride for passengers (IAM, 2016) "A movement mechanism for moving said gearshift in a substantially h-shaped configuration to engage gears" (Ikeya, 2004)
E.	**F25-**Idling of engine	" A vehicle's engine is running while the vehicle is not in motion" (EMA, 2014)
S.	**F26-**Distraction (music, smoking, eating)	"A negative, connotation of negative activities but also clearly implies a more important positive state of attraction"(Hancock et al., 2009) "Increases risk-taking behavior and impairs judgement and perception" (Harris, 2000)
S.	**F27-**Dangerous overtaking	"The act of one vehicle going past another slower moving vehicle, travelling in the same direction, on a road" (Blanco, 2014)
E.	**F28-**Traffic volume	"Traffic volumes may be expressed in terms of average daily traffic or design hourly volumes" (TxDOT, 2014)

NOTE: Clusters are as: S; Safety, E; Environment, V; Vehicle.

4. Validation and Verification of Driver's Green Adaptive Travel Behaviors

In second phase, the research conducted an expert input study to validate the findings on phase one. Besides, the expert input study has been conducted with the aim of verifying the greenery value impact (GVI) of those validated factors to determine the final Green Adaptive Travel Behaviors (GTAB) factors.

The expert input study has applied the Grounded Group Decision Making (GGDM) method developed by Lamit et al. (2013c). According to GGDM method, a field expert Delphi structured close group discussion was applied for the expert input study, which is the most applicable group decision-making method (Hilbert et al., 2009; Green et al., 2007). A structured fixed format self-reporting questionnaire form was designed filled up by the experts. The interviews validated based on expert's judgment in the scale of 1 for weak to 5 for excellent. Based on purposive sampling GGDM method the Delphi process has been conducted in three (3) validation sessions, and total of eight experts were involved (see Table 4). First three of experts were in the field of transportation planning (who participated in 1st decision-making session), second three of experts had knowledge in transportation engineering (who participated in 2nd decision-making session), and the other two exerts had knowledge in driver behavior assessment and modeling (who participated in 3rd decision-making session). Moreover, the specific value for each validation session of Delphi procedure has been assigned based on the relevancy of the experts' field to the research topic. Hence, the researcher appointed session value (SV) as 2 for 1st validation session that is different from session values (SV) appointed for other two sessions; because in this study transportation planning (i.e. 1st validation session experts' field) has lower impact than green transportation (i.e. 2nd validation session experts' field), and driver behavior assessment and modeling (i.e. 3rd validation driver behavior assessment and modeling) (see Table 4, SV columns). According to GGDM method, sequential and spiral involvement of experts in Delphi procedure makes more normalized and precise final group decision.

Adapted from Lamit et al. (2013c), $FW(a_i)$ (Equation 1) is to calculte final weight (FW) of sub-issue number 'i', $(\boldsymbol{a_i})$, of the discussion.

$$\boldsymbol{FW(a_i)} = \left(\sum_{\boldsymbol{j}=1}^{\boldsymbol{n}} (\mathbf{min}\{\boldsymbol{WP_j},\ \boldsymbol{WPr_j}\} \times \boldsymbol{SV_j}) \right) \times \boldsymbol{a_i}, \quad \text{for } i = 1,2,3,\ldots,m \qquad (1)$$

where:

$\boldsymbol{WP_{ij}}$, *refers to assigned weight by participants number 'j' in close group discussion for sub-issue 'a_i ',*

$\boldsymbol{WPr_{ij}}$, *refers to assigned weight by resource(s) relevant to the issue, whom introduced by participants number 'j' in close group discussion for sub-issue 'a_i ',*

$\boldsymbol{a_i}$, *refers to sub-issue of discussion,*

$\boldsymbol{FW(a_i)_{max}}$, *referred to maximum possible weight can be given for sub-issue 'a_i',*

$\boldsymbol{SV_j}$, *refers to CGD sessions value (SV) considered by the decision researcher which the CGD session included participantnumber 'j',*

Equation (2) indicates the consensus calculation in GGDM for sub-issue 'a_i'. If the final consensus calculated more than 70% the alternative is selected, and that factor is approved.

$$\boldsymbol{FW(a_i)} \,/\, \boldsymbol{FW(a_i)_{max}} = \textbf{Consensus in \%} \qquad (2)$$

GGDM Data Analysis

According to Table 4, each expert has been asked to assign the weight for each factor. Each expert has been asked to introduce any other expert to validate the list of factors, if needed. For example, expert 1 has introduced the expert 4 (i.e. WPr = c-WP4). Then, according to WP column of the participant 1, the researcher had to select the minimum between 5 and 3 as the weighting value indicated by participant 1 and 4, respectively, for the factor 'F3' (i.e. Slow once realizing bike lanes for cyclist crossing) which equals 3. Then, researcher put this value (i.e. c-**WP**) in the column c-WP as participant 1 records. For second and third sessions, similar process of data analysis has been conducted. For example, for the factor 'F3' (i.e. F3-Slow once realizing bike lanes for cyclist crossing) the following calculations have been performed;

$\boldsymbol{FW(F_3)}$=
(3*2)+(5*2)+(3*3)+(5*3)+(5*3)+(5*3)+(5*3)=91

$\boldsymbol{FW(F_3)} \,/\, \boldsymbol{FW(C_1)_{max}}$ = 91 / 100 = 91%

In some cases the expert did not introduced any other experts; for example, participant 3 (i.e. WPr = -). Also, in some cases the exert did not appoint any value, and accepts all identified by his/her introduced expert. For example, participant 8 did not rank (i.e. WP = -) but introduced expert 7, and claimed he accepts all weighting values appointed by expert 7.

5. Results and Discussion

The increasing population growth and rapid urbanization are the major factors increase vehicle usage and mobility which further leads to CO_2 and GHG emissions, and fuel sources consumption. Hence, the green transportation has been raised to overcome ever-increasing rate of fuel consumption, hazardous gases emission, and road fatalities. But, the concept of green driver has not been operationalized which the current study has established it as driver's green adaptive travel behaviors (GATB). Investigating the GATB factors were intensively needed which can aid transportation engineers and planners with safe, low-energy and low-emission transportation.

A critical literature review has identified the driver's adaptive travel behaviors. It was found out that previous driver behavior studies have studied only the technological and personal mode of adaptation behavior; and, psychological and psychological adaptations have not been investigated, since they are dynamic and cannot be simply foreseen. The identified technological and personal-based adaptive travel behaviors were folded into three clusters; i) driver's adaptive travel behaviors for personal and physical safety (S.), ii) driver's adaptive travel behaviors for environment protection (i.e. road and street design and street characteristics) (E.), and iii) driver's adaptive travel behaviors for vehicle functional and operational modes (i.e. vehicle operations and design) (V.). A critical literature review has come up with total twenty eight (28) factors. To validate these factors, the research has conducted an expert input study with a group of experts practicing green transportation. The group of experts has validated the factors applying GGDM method and Delphi procedure.

Table 4. Summary of GGDM data analysis on driver's adaptive travel behaviors factors

Cluster	**Driver's adaptive travel behaviors factors**	**Validation session 1**										**Validation session 2**										**Validation session 3**							**Cons. (%)**	**GGDM Consensus**
		Participant 1			Participant 2			Participant 3				Participant 4			Participant 5			Participant 6				Participant 7			Participant 8					
		WP	**WPr** = c-WP4	c-**WP**	**WP**	r-**WP** = c-WP4	c-**WP**	**WP**	**WPr** = WP7	c-**WP**	**SV**	**WP**	**WPr** = c-WP5	c-**WP**	**WP**	**WPr**= WP7	c-**WP**	**WP**	**WPr** = c-WP5	c-**WP**	**SV**	**WP**	**WPr** = -	c-**WP**	**WP**	**WPr** = WP7	c-**WP**	**SV**		
E.	**F 1**-Remove unnecessary misalliances from car	4	4	4	3	4	3	-	5	5	2	4	4	4	4	5	4	2	4	2	3	5	-	5	-	5	5	3	84	Aprv.
S.	**F 2**-Slow speed in and near to pedestrian crossing	5	4	4	4	4	4	-	5	5	2	4	4	4	4	5	4	3	4	3	3	3	-	3	-	5	5	3	81	Aprv.
S.	**F 3**-Slow once realizing bike lanes for cyclist crossing	5	3	3	4	3	3	-	5	5	2	3	5	3	5	5	5	5	5	5	3	5	-	5	-	5	5	3	91	Aprv.
S.	**F 4**- Realize visual Obstacles to manage the speed	4	5	4	4	5	4	-	4	4	2	5	3	3	3	4	3	4	3	3	3	4	-	4	-	4	4	3	75	Aprv.
E.	**F 5**-Use traffic calming devices	4	3	3	5	3	3	-	2	2	2	3	4	3	4	2	2	4	4	4	3	2	-	2	-	2	2	3	55	n-Aprv.
E.	**F 6**-Use first available public parking	4	5	5	5	5	5	-	3	3	2	5	5	5	5	3	3	5	5	5	3	3	-	3	-	3	3	3	83	Aprv.
E.	**F 7**-Using first available on-street parking	4	4	4	5	4	4	-	3	3	2	4	5	4	5	3	3	4	5	4	3	5	-	5	-	3	3	3	82	Aprv.
S.	**F 8**-Keep a safe gap to avoid sharp breaking	5	5	5	4	5	4	-	4	4	2	5	5	5	5	4	4	2	5	2	3	4	-	4	-	4	4	3	83	Aprv.
E.	**F 9**-Use satellite navigation systems for short path to destination	5	5	5	5	5	5	-	4	4	2	5	4	4	4	4	4	5	4	4	3	4	-	4	-	4	4	3	84	Aprv.
S.	**F10**-Slow once realizing sidewalk steepness for pedestrian crossing	4	5	4	4	5	4	-	5	5	2	5	3	3	3	5	3	5	3	3	3	5	-	5	-	5	5	3	83	Aprv.

Cluster	Driver's adaptive travel behaviors factors	Validation session 1										Validation session 2										Validation session 3							Cons. (%)	GGDM Consensus
		Participant 1			Participant 2			Participant 3				Participant 4			Participant 5			Participant 6				Participant 7			Participant 8					
		WP	**WPr** = c-WP4	c-**WP**	**WP**	r-**WP** = c-WP4	c-**WP**	**WP**	**WPr** = WP7	c-**WP**	**SV**	**WP**	**WPr** = c-WP5	c-**WP**	**WP**	**WPr**= WP7	c-**WP**	**WP**	**WPr** = c-WP5	c-**WP**	**SV**	**WP**	**WPr** = -	c-**WP**	**WP**	**WPr** = WP7	c-**WP**	**SV**		
S.	**F11**-Avoid to non-necessary overtaking	4	4	4	3	4	3	-	5	5	2	4	4	4	4	5	4	2	4	2	3	5	-	5	-	5	5	3	84	Aprv.
S.	**F12**-Keep a safe gap to avoid stop-and-go driving	4	5	4	4	5	4	-	4	4	2	5	3	3	3	4	3	4	3	3	3	4	-	4	-	4	4	3	75	Aprv.
S. & E.	**F13**-Plan ahead to avoid stop-and-go driving	5	3	3	4	3	3	-	5	5	2	3	5	3	5	5	5	5	5	5	3	5	-	5	-	5	5	3	91	Aprv.
E.	**F14**-Close the windows one using AC (air-condition)	5	4	4	4	4	4	-	5	5	2	4	4	4	4	5	4	3	4	3	3	3	-	3	-	5	5	3	81	Aprv.
V. &E.	**F15**-Use smart speed adaptation system	5	5	5	4	5	4	-	4	4	2	5	5	5	5	4	4	2	5	2	3	4	-	4	-	4	4	3	83	Aprv.
V.	**F16**- Chang car oil by specific traveled millage	4	5	5	5	5	5	-	3	3	2	5	5	5	5	3	3	5	5	5	3	3	-	3	-	3	3	3	83	Aprv.
E.	**F17**- Adjust air-condition operative hours	4	5	4	4	5	4	-	4	4	2	5	3	3	3	4	3	3	3	3	3	4	-	4	-	4	4	3	75	Aprv.
E.	**F18**- Adjust furniture materials compatible with region climate	5	5	5	5	5	5	-	4	4	2	5	4	4	4	4	4	4	4	4	3	4	-	4	-	4	4	3	79	Aprv.
E. & S.	**F19**- Use moderate speeds and keep it steady	4	4	4	5	4	4	-	3	3	2	4	5	4	5	3	3	4	5	4	3	5	-	5	-	3	3	3	82	Aprv.
E.	**F20**- Use the engine brake instead of brake pedal	3	4	3	5	4	4	-	3	3	2	4	5	4	5	3	3	4	5	4	3	5	-	5	-	3	3	3	80	Aprv.
E.	**F21**- Brake with smooth deceleration	4	4	4	4	4	4	-	5	5	2	4	4	4	4	5	4	1	4	1	3	3	-	3	-	5	5	3	75	Aprv.

Cluster	Driver's adaptive travel behaviors factors	Validation session 1										Validation session 2										Validation session 3							Cons.	GGDM
		Participant 1			Participant 2			Participant 3			SV	Participant 4			Participant 5			Participant 6			SV	Participant 7			Participant 8			SV		
		WP	**WPr** = c-WP4	**c-WP**	**WP**	r-**WP** = c-WP4	**c-WP**	**WP**	**WPr** = WP7	**c-WP**		**WP**	**WPr** = c-WP5	**c-WP**	**WP**	**WPr**= WP7	**c-WP**	**WP**	**WPr** = c-WP5	**c-WP**		**WP**	**WPr** = -	**c-WP**	**WP**	**WPr** = WP7	**c-WP**			
E.	**F22-** Open or close window(s) using smart system	4	5	5	5	5	5	-	3	3	2	5	5	5	5	3	3	5	5	5	3	2	-	2	-	3	3	3	80	Aprv.
E.	**F23-** Switch off the lamps once not needed	1	4	1	4	4	4	-	5	5	2	2	5	2	5	5	5	4	5	4	3	5	-	5	-	5	5	3	83	Aprv.
E.	**F24-** Change to highest possible gear	4	5	4	4	5	4	-	4	4	2	5	3	3	3	4	3	4	3	3	3	2	-	2	-	4	4	3	69	n-Aprv.
E.	**F25-** Idling of engine	5	5	5	5	5	5	-	4	4	2	5	4	4	4	4	4	5	4	4	3	4	-	4	-	4	4	3	84	Aprv.
S.	**F26-** Distraction (music, smoking, eating)	5	5	5	5	5	5	-	4	4	2	5	4	4	4	4	4	4	4	4	3	4	-	4	-	4	4	3	79	Aprv.
S.	**F27-** Dangerous overtaking	5	3	3	4	3	3	-	5	5	2	5	5	5	5	5	5	5	5	5	3	5	-	5	-	5	5	3	97	Aprv.
E.	**F28-** Traffic volume	5	5	5	4	5	4	-	4	4	2	5	3	3	3	4	3	4	3	3	3	4	-	4	-	4	4	3	77	Aprv.

Note. **WP:** Participant's Rate to the validation aspect, c-**WP:** conclusion of Participant's Rate to the validation aspect considered as $min\{WP_j\ ,\ WPr_j\}$, **WPr:** Participant introduced resouceRate to the validation aspect, -: Participant did not provide value**, SV:** CGDSession Value considered by the GGDM researcher, **Aprv**.: the validation aspect is approved based on GGDM Consensus rate of more than 70% agreement, **n-Aprv**.: the validation aspect is not approved based on GGDM Consensus rate of not more than 70% agreement.

The GGDM analysis result shows that expert input reached more than 70% saturation for all factors exempt two factors. The two factors,'F5-Use traffic calming devices' and 'F24-Change to highest possible gear', have been dropped from the list of factors because the analysis resulted with less than 70% saturation, 55% and 69%, respectively (see Figure 7).

The purpose of factors elimination was to re-verify any factors that adequately contribute to both attributes in the study (safety and emission). In this view, installation of traffic calming device (factor F5) is vital for the safety among drivers, pedestrians, and motorists as it aims to reduce speed or restrain speeding behavior. DETR (Department of Environment, Transportaion, and Region, 2005) has reported that operating speed reductions equal to 25 km/h at gateways with other traffic calming devices in the urban area. However, in the perspective of emission reduction, traffic calming device insufficiently portrays unfavorable results. For example, provision of speed humps under high, moderate, and low traffic intensity has increased vehicle emissions, fuel consumption and traffic delay (Höglund and Niittymäki, 1999). With provision of speed humps at peak hours, the amount of fuel consumption was rising at 18.99% from its initial amount (without speed humps), which is 39.65L. Subsequently, the emission levels were also increasing at 26%, 32%, and 62% for NOx, CO, and HC respectively. Meanwhile, at a lower traffic intensity, the amount of fuel consumption was increasing at 13.6% from its initial amount (without speed humps), which is 4.4L. Consequently, the emissions levels were also rising at 18.72% (NOx), 31.96% (CO), and 76.2% (HC) (Höglund and Niittymäki, 1999).

Aggressive and non-aggressive gear shifts may implies different emissions pattern over a trip which is due to the 'vrooming' effect that forcefully surged the engine and increase fuel consumption and tailpipe emission level (Beckx et al. 2007). The effects of gear shifting happen occasionally and subjected to the manually operated vehicle. As more auto transmission vehicle is produced nowadays, the gear changing effects on emission is almost neglected in automotive industries. More and more cars are now being offered with 'automated manual' transmissions, clever hydraulic and electronic systems take care of the clutch operation and gear changes to offer a fuel consumption saving compared both with more conventional autos and even manual transmissions (Kroll et al., 2014). Therefore, factor F24 was eliminated from the rest of factors due to its insufficient contribution in translating GATB.

Finally, the GGDM analysis resulted with twenty six (26) GATB factors (see Figure 7 as the hierarchy structure of the GTAB factors); within which 'F27- Dangerous overtaking' and 'F3- Slow once realizing bike lanes for cyclist crossing' have received the highest Greenery Value Impact (GVI), 97% and 91% respectively. It was observed that higher overtaking speed is associated with the aggressive behavior in overtaking maneuvers, therefore, the overtaking driver perceives a shorter gap with the oncoming traffic, hence a shorter overtaking time and safety margin (Hassan et al., 2014). In contrast, dangerous overtaking at an intersection has become the voluntary risk factors that contributes to accident likelihood (Clarke et al., 2005). In the perspective of behavioral studies, the situation described such as; 'Someone cuts in and takes the parking spot you have been waiting for' and 'Someone is driving very close to your rear bumper' elicited the highest amount of anger (Lajunen and Parker, 2001). Meanwhile, 'A pedestrian walks slowly across the middle of the street, slowing you down' seem to be the least irritating situations whereas drivers' reactions to the situations 'Someone is driving well above the speed limit' and 'Someone is weaving in and out of traffic' were the least extreme (Lajunen and Parker, 2001). These reactive aggressions among drivers seem to depend not only on the level of anger, but also on situational characteristics and the nature of the provocative act. On the other hand, when a vehicle overtakes from a particular ramps into a main road, the following vehicles shall experience abrupt deceleration and gradually all vehicles on ramp will decelerates, yet their fuel consumptions and tailpipe emission will eventually increase (Tang et al., 2015). Consequently, overtaking factor has significant role in association with safety and emission attributes.

The research expresses that the GATB factors are the factors extracted from related literatures, which can be considered as the common factors in evaluating and assessing any individual green driver's behaviors. Referring to Keyvanfar et al. (2014) adaptive behavior can be conscious or unconscious, and multiple environmental factors can affect it; therefore all determined GATB factors can be adjusted according to different weather condition, driving cultures, environmental situations, vehicle control techniques and technologies, traffic rules and regulations, urban design and planning guidelines and standards. Hence, the GATB factors can be not limit to the finalized one, and can be amended to the specific transportation rules and conditions.

This research has the ultimate goal of development of Green driver behaviour index assessment model (which is not in the scope of this paper). This model can be used to measure the GVI of driver behaviours towards higher-safety and lower-emission style of driving. The index model will develop a correlation formulate of all driver's GATB factors, and consequently, will evaluate the greenery grade of any individual driver based on; i) green: Very committed driver to green driving, ii) Grey: Medium committed driver to green driving, and iii) Black: Non committed driver to green driving).

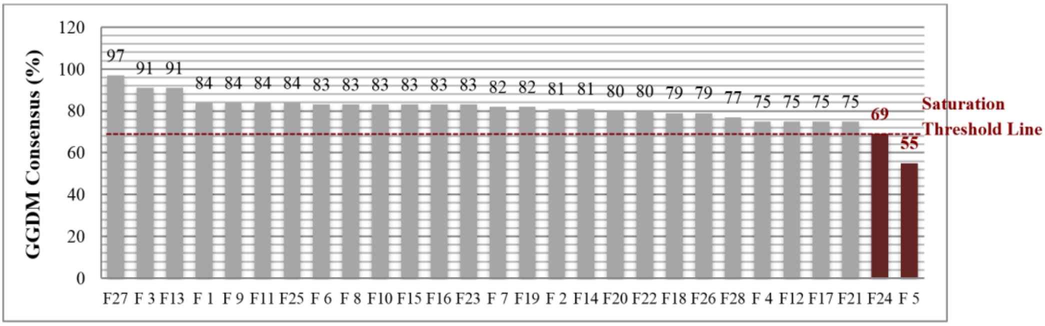

Fig. 7. The hierarchy structure of the GTAB factors resulted from GGDM analysis; factors F24 and F5 have been dropped from the list of factors because are lower than 70% saturation threshold

6. Conclusion and Recommendations

Due to ever-increasing travel demand, governments and authorities have allocated massive investment into green transportation. They are attempting to change driver's beliefs, attitudes, preferences, and social and physical determinants in pursuit of green transportation goals (i.e. less pollution and emissions, less fuel consumption, higher safety and health). To achieve this goal, it is essential to create engineering breakthrough to drastically fulfill it, which can overlap with other transportation planning concerns, such as, low-energy city, green transportation, sustainable urban development, air quality, and other related environmental and social concerns promote green travel behavior. Transportation professionals pursue an innovative technique to measure the impact of driver's travel behavior changes to green transportation goal. In this regards, it is needed to develop the Green driver behaviour index assessment model. This study reported the first stage of the index model development, which is to determine the driver's green adaptive travel behaviors (GATB) factors. The research determined total twenty six (26) Driver's GATB factors. The Greenery Value Impact (GVI) of each factor has been calculated that will be involved as the weightage coefficient of each factor in the index model (it will be presented in future works). Among GATB factors 'F27- Dangerous overtaking' has received the highest value (97%) followed with 'F3- Slow once realizing bike lanes for cyclist crossing' (91%). In contrast, 'F4- Realize visual Obstacles to manage the speed' and 'F21- Brake with smooth deceleration' has received the lowest value (77%) among other factors. Two of the initial factors;'F5-Use traffic calming devices' (55%), and 'F24- Change highest possible gear' (69%) could not reach the 70% saturation; hence, they have been dropped from the final list of GATB factors.

Research concludes also the transportation professionals can use the list of GATB factors as the decision support checklists tool for green transportation, and also, green neighborhood assessment. They can use it to fulfill the requirements of green accreditation in urban streets. Unlike expensive implementation of costly technologies and techniques in transportation, applying this innovative technique shall be more beneficial technique for reducing emissions and fuel consumption.

Further study is needed to investigate driver's decision-making on his/her green travel behavior. Such research may aid to understand why and how drivers make decision to change their travel behavior to green travel behavior. The GATB efforts are not limited to technology and practice; but also can include education and enforcement to driving regulations in order to interconnect driver, technology, environment, and vehicle. The future study can measure the level of concordance of opinions of experts in GTAB factor validation, in order to reach the precise greenery value impact (GVI) of each factor. In addition, as future study, the Green driver behaviour index assessment model will be developed, and then implemented for several pilot studies.

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