Investigating the feasibility of a locally developed carbon-offsetting scheme: The case of the Drifters Desert Nature Reserve

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Abstract

In the context of both climate change and peak oil, it is clear that the tourism industry cannot continue with a business-as-usual approach. Unfettered fossil fuel use is no longer an option and novel approaches need to be explored in order to change the configuration of energy systems. Transport is particularly energy intense and consequently, since it involves travel, so is tourism.

The Drifters Desert Nature Reserve (DDNR) is probably a net carbon sink. The property is large and has thousands of long lived trees and bushes: but this would be an 'easy out' in an industry which is has a reputation for evading tough questions. Are there affordable techniques that can be employed by the Reserve that will reduce its carbon footprint and enable it to move toward being entirely carbon neutral, without relying on sequestration?

A willingness to pay (WTP) survey investigating if clients were prepared to pay a voluntary amount towards reducing the emissions of the DDNR, thereby offsetting some of their own emissions, was conducted; 121 questionnaires were completed. The results were extrapolated out to represent the WTP of the 1055 clients that visited the DDNR in the last year. It was found that 73% of all the clients who stay at the DDNR are willing to pay toward helping the DDNR change the way its systems are configured as a means to offset some of their own emissions debt in getting to the reserve. Lodge clients were prepared to pay almost double the amount clients staying at the campsite would consider. In both cases, WTP was around 10% of the value of the accommodation package chosen.

The fossil fuel use and consequent carbon dioxide debt of the DDNR was calculated and emissions were found to be in the region of 30 tonnes per annum. As per the case in the greater Namibia, transport is responsible for the bulk of the carbon dioxide output, with energy provision in this off-grid reserve being a close second. Of four potential interventions considered, two were found to be financially viable, regardless of the WTP of clientele.

It is speculated that WTP on a small scale is administratively laborious and the potential contribution of a voluntary offsetting payment was perhaps not high to justify the implementation of the scheme. It was however found that reconfiguring the energy systems would definitely be a worthwhile exercise.

On corporate level where efficiencies of size amplify gains, Drifters, as a group of 14 lodges and an overland company, may well find that a transparent voluntary emissions reduction (VER) payment, ring-fenced, appropriately used, and properly implemented, is worthwhile.

Ethically, however, injecting VER payments into a balance sheet is problematic, especially where the payback period of the technological interventions is short and the benefits derived are long term.

Opsomming

Die gebruik van fossielbrandstowwe wat in die huidige tydsgewrig tot die opwekking van oormatige kweekhuisgasse lei is nie langer aanvaarbaar nie en innoverende opsies om die voortgesette generasie van energie te verseker, sal nagestreef moet word. Een van die grootste verbruikers van energie is vervoer, en vervolgens is dit ook die geval dat toerisme, wat swaar op vervoer staatmaak, 'n groot gebruiker van energie is.

Aangesien daar etlike gevestigde bome en bosse op hierdie woestynreservaat is, is die Drifters Desert Nature Reserve (DDNR) moontlik 'n netto bespaarder van koolstofgasse, maar dit kan nie sondermeer daargelaat word in 'n bedryf wat bekend is daarvoor dat dit graag die moeilike vrae vermy nie. Daar is dus gevra: is daar bekostigbare tegnieke wat moontlik by die DDBR aangewend kan word om die koolstofvoetafdruk te verminder en dit in staat kan stel om totaal koolstofneutraal te word, sonder om op ingryping staat te maak?

Navorsing is gedoen en 121 vraelyste is voltooi om vas te stel of kliente gewillig sou wees om 'n vrywillige bydrae te maak om die afskeid van koolstof te beheer en daardeur hul eie koolstofvoetafrdruk te verminder, in 'n sg "gewilligheid om te betaal" oftewel "willingness to pay" (WTP) opname. Die resultate is deurgevoer as verteenwoordigend van die 1 055 kliente wat verlede jaar die oord besoek het. Daar is gevind dat 73% van die kliente wat die oord besoek bereid sou wees om die DDNR geldelik te help om sy stelsels te verander as 'n teenrekening om hul eie koolstofbesoedeling op pad daarheen te vergoed. Kliente wat die losie gebruik het was bereid om meer te betaal as diegene wat by die kampeerterrein tuisgegaan het.

Die hele reservaat se jaarlikse koolstofdioksied debiet is bereken, en die jaarlikse opwekking is op ongeveer 30-tonne vasgestel. Nes in Namibie as geheel is vervoeruitlaatgasse verantwoordelik vir die oorgrote meerderheid opwekking, met die voorsiening van energie by die afgelee oord kort op sy hakke. Van die vier moontlike ingrypings wat oorweeg is, is twee finansieel die moeite werd gevind, ongeag die kliente se gewilligheid om geldelik by te dra. Die bestuur van aanvraag is ook oorweeg, en hoewel dit nie gekwantifiseer is nie, is dit nes die moontlikheid van tegnologiese innovering, duidelik deel van die oplossing,

Daar is gevind dat 'n stelsel van betaling op plaaslike vlak moeilik sou wees om die administreer, en aangesien selfs die gewilliges nie oorgretig is nie, is daar tot die gevolgtrekking gekom dat dit nie die moeite sou loon nie. Ongeag bogenoemde beginsel van toersitebydraes is daar gevind dat dit ongetwyfeld die moeite werd sou wees om die energiestelsels aan te pas. Maar dit sal nie noodwendig op 'n korporatiewe of 'n makro-skaal werk nie, veral nie waar grote 'n rol speel nie. As maatskappygroep mag Drifters vind dat met 'n deursigtige, vrywillige uitlaat-verminderingspaaiement, wat afgebaken, korrek aangewend en effektief bestuur word, die kool die sous werd sou wees.

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Contents

List of acronyms and abbreviations

AC	Alternating current
Ah	Amp hour
APD	Air passenger duty
ASPO-SA	Association of Peak Oil South Africa
CBEND	Combating Bush Encroachment for Namibia's Development
CCX	Chicago Carbon Exchange
CERs	Certified emission reductions
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CV	Cape Town to Victoria Falls tour (Drifters)
DC	Direct current
DDL	Drifters Desert Lodge
DDC	Drifters Desert Camp
DDNR	Drifters Desert Nature Reserve
DC	Direct current
DSM	Demand side management
DRFN	Desert Research Foundation of Namibia
ECB	Electricity Control Board
EU	European Union
EU ETS	European Union Emissions Trading System
FEDHASA	Federation of Hospitality Associations of Southern Africa
FIT	Fully independent traveller
FENATA	Federation of Namibia Tourism Associations
GDP	Gross Domestic Product
GEF	Global Environmental Fund
GHG	Greenhouse gas
GW	Gigawatt
HDVC	High voltage direct current
IATA	International Air Transport Association
IPCC	Independent Panel on Climate Change
IPP	Independent power producer
ISO	International Standards Organisation
kVa	kiloVolt amp
kW	kiloWatt, 1 000 Watts
kWh	kiloWatt hour
LED	Light emitting diode
l	Litre
LPG	Liquid petroleum gas
NAM-PLACE	Namibian Protected Landscape Conservation Areas Initiative
MET	Ministry of Environment and Tourism
MME	Ministry of Mines and Energy
NAM	Namibia tour (Drifters)
PV	Solar photovoltaic
PVP	Solar photovoltaic pump (water)
REEEI	Renewable Energy and Energy Efficiency Institute

SANBI	South African National Biodiversity Institute
SRES	Special Report on Emissions Scenarios
SRF	Solar Revolving Fund
NNF	Namibia Nature Foundation
PV	Photovoltaic
PVP	Photovoltaic pump
REEEI	Renewable Energy and Energy Efficiency Institute
RET	Renewable energy technology
RED	Regional Electricity Distributor
SANBI	South African National Biodiversity Institute
SNC	Second National Communication of Namibia per the UNFCCC
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
UNWTO	United Nations World Travel Organisation
US EPA	United States Environmental Protection Agency
V	Volt
VERs	Voluntary emission reductions
W	Watt
WPEP	White Paper on Electricity Policy
WTO	World Tourism Organisation
WTP	Willingness to pay
WTTC	World Travel and Tourism Council

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1.1 Introduction

Sustainable tourism is an anomaly. Can tourism, which by its very nature, under current technological states, ever be truly sustainable? With upward of 10% of local gross domestic product being sourced from tourism the United Nations World Tourism Organisation (UNWTO) contends that it is essential to the development of the third world (United Nations World Travel Organisation, 2009). The UNWTO also maintains that tourism can be contribute to sustainable development through helping to achieve the Millennium Development Goals, and therein is the rub: whilst recognising that tourism contributes to global warming the UNWTO pursues the tagline of “committed to tourism, travel and the Millennium Development Goals” (United Nations World Travel Organisation 2009:7), thus tourism has to mediate between the possibly conflictual objectives of a reduction in its contribution to global warming, and contribution to poverty alleviation and sustainable development. This study quantifies the contribution that a definable tourism organisation, the Drifters Desert Nature Reserve (DDNR), makes toward global warming through using fossil fuels, and then looks at ways of using a customer-centric financial contribution to reduce fossil fuel dependency and move toward a more sustainable form of tourism.

1.2 Global warming

According to the IPCC: “warming of the environment is now unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level. Eleven of the last twelve years (1995-2006) rank among the warmest years in the instrumental record of global surface temperature since 1850” (IPCC 2007:30). In terms of the causes of change, the IPCC states that carbon dioxide (CO_2) is the most important of the greenhouse gases (GHGs) with emissions of CO_2 growing from 21 gigatonnes in 1970 to 38 gigatonnes in 2003, an 80% increase. Sectors with the fastest growing emissions are transport, energy provision and industry (Intergovernmental Panel on Climate Change, 2007). Other GHGs include methane (CH_4) and nitrous oxide (N_2O), amongst others, but since CO_2 is the most prevalent of the GHGs all GHGs are often collectively referred to as units of carbon dioxide equivalent or CO_{2e} (International Standards Organisation, 2006).

The IPCC further state that there is “very high confidence”, which it defines as a greater than 90% chance (IPCC 2007:37), that the combined effect of anthropogenic activities has resulted in a warming of the Earth due to a CO_2 derived increase in radiative forcing[1] of more than 1.6 W/m² [2], and an increase in radiative forcing due to a combination of increased concentrations of CO_{2e} of more than 2.3 W/m² [3] (Intergovernmental Panel on Climate Change, 2007). The first IPCC report, completed in 1990, predicted an average decadal increase in global temperatures of between 0.15 and 0.3℃ from 1990 to 2005 and act ual temperature measurements over the

[1] Radiative forcing is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism (Intergovernmental Panel on Climate Change, 2007).

[2] With an uncertainty interval of + 0.6 W/m² - + 2.4 W/m² (Intergovernmental Panel on Climate Change, 2007).

[3] With an uncertainty interval of + + 2.1 W/m² - + 2.5 W/m² (Intergovernmental Panel on Climate Change, 2007).

corresponding period now validate this prediction with a verified increase of around 0.2℃ per decade (Intergovernmental Panel on Climate Change, 2007).

The IPCC Special Report on Emissions Scenarios (SRES) of 2000 described four qualitative storylines, A1, A2, B1,and B2, each that results in a different future for the planet (Intergovernmental Panel on Climate Change, 2000a). Various assumptions are made about future population growth, technological change and economic development producing a different outcome for each storyline. In the 2007 IPCC assessment these storylines are further refined with a number of robust findings being the result. Findings include, amongst others, that the acidity of the oceans has increased; GHG emissions have increased by 70% between 1970 and 2004; CH_4 and CO_2 levels exceed their natural range over the last 650 000 years; global warming in the last 50 years is very likely - a greater than 90% chance - to be driven by an increase in GHGs due to anthropogenic activity; and for the next 20 years, average decadal increases of 0.2℃ per decade are projected across all SRES scenarios (Intergovernmental Panel on Climate Change, 2007).

In the African context the near-term result of global warming includes that by 2020 between 75 and 250 million people are likely to be exposed to climate change-induced water stress; rain-fed agricultural yields could reduce by up to 50% in some areas, and access to food and general agricultural production are likely to be compromised which will increase rates of malnutrition and reduce food security (Intergovernmental Panel on Climate Change, 2007). By 2080, under all storylines and climate scenarios, there is a predicted 5 to 8% increase in arid and semi-arid land areas in Africa (Intergovernmental Panel on Climate Change, 2007).

Adding gravity to the dire predictions around climate change is the fact that oil is a finite resource. According to the Association of Peak Oil - South Africa oil now accounts for 35% of the world's energy supply with its most important use being for transport with around 90% of the world's transport being dependent on oil, and consequently, tourism, by definition involving travel, is an oil-dependent industry (Wakeford, 2007). Oil, being finite, naturally follows a rough bell-curve of increases in production due to new discoveries and subsequent extraction through to a decline in production and eventual depletion. Consumption has exceeded discovery each year since 1981 with current ratios being one barrel discovered for each five to six barrels consumed (Wakeford, 2007).

Inspired in part by the need to reduce the rate at which the globe is warming the market penetration of renewable energy is exponential. Of approximately 300 Gigawatt (GW) of electricity generating capacity added globally during 2008 and 2009[4], 140GW came from renewable energy sources (Intergovernmental Panel on Climate Change, 2011). Grid-connected photovoltaic energy was the fastest growing sector with a 50% increase in capacity, followed by wind energy with 30% (Intergovernmental Panel on Climate Change, 2011).

As a measure to curb the expansion of carbon based growth the United Nations Framework Convention on Climate Change, the UNFCCC, established a cap-and-trade system for GHG emissions, the Kyoto Protocol. The protocol is an international treaty that imposes national caps on GHGs for developed countries, so-called 'Annex 1 parties', for countries that ratified

[4] A large conventional electricity plant is perhaps around 500MW, so 300GW, or 300 000MW, is the equivalent of 600 electricity plants.

the protocol (Turpie et al. 2010; United Nations Framework Convention on Climate Change 2011). A total of 193 countries are signatories to Kyoto which legally binds developed countries to emission reduction targets with the initial commitment period ending in 2012 (United Nations Framework Convention on Climate Change, 2011a) and which was extended by the European Union and some other developed countries for a second period to 2020 at the Conference of the Parties, or COP 17, that was concluded in Durban late in 2011 (United Nations Framework Convention on Climate Change, 2011b).

The mechanism adopted for the cap-and-trade system is known as the Clean Development Mechanism (CDM) where developing countries - non-Annex 1 parties - can formally register emission reduction schemes and obtain certified emission reductions (CERs) or credits which are purchased by Annex 1 parties, developed countries, to offset their own emissions and enable them to meet emission reduction targets (United Nations Framework Convention on Climate Change, 2011a). COP 17 also produced the Durban Platform for Climate Change which for the first time legally committed all signatories to the UNFCCC, including the world's three largest emitters, the United States, China and India, to reaching a legally binding agreement on reducing GHG emissions by 2015 (United Nations Framework Convention on Climate Change, 2011b).

Namibia is a signatory to the UNFCCC and the Kyoto Protocol but its national commitment, as a non-Annex 1 party, remains one of monitoring and reporting and not reducing GHGs (Ministry of Mines and Energy, 2011a). At this point there are no CDM projects registered in Namibia and as such Namibia has not benefitted from the trading of CERs which, due to Namibia being particularly susceptible to the consequences of climate change[5], remains an anomaly which needs to be addressed by the UNFCCC[6]. The 2007 IPCC assessment contends that there is high agreement that instruments and policies are available to governments to stimulate mitigation action (Intergovernmental Panel on Climate Change, 2007) and that one of the results of the pursuit of these policies will be that tradable permits such as the CERs established under the Kyoto Protocol will result in a carbon price being established on goods and services (Intergovernmental Panel on Climate Change, 2007).

It is thus clear that global warming and emission reductions have already entered into mainstream consciousness and as the COP meetings move the UNFCCC forward and more countries buy in to the need to reduce GHG emissions and introduce renewable energy so the definition of what constitutes a CER will widen.

1.3 The local context: Drifters Desert Nature Reserve

Drifters Adventours (Drifters) conducts participation-based overland tours and safaris and self-drive tours, and has a number of accommodation facilities. It was started in 1983 and, with the ending of apartheid in 1994 in South Africa, Drifters grew exponentially in the mid and late 1990's. Today it is one of the largest tourism operations in Southern Africa with 14 accommodation establishments, a total of 11 itineraries, 300 scheduled departures, and around 2 500 to 3 000 guests per annum (Drifters Adventours, 2011). The majority of clients are sourced internationally.

[5] Elaborated in point 2.3.
[6] CERs are discussed further in point 2.5.

The Drifters Desert Nature Reserve, the DDNR, is a freehold property officially designated as Excelsior 127. It was purchased by Drifters Safaris Namibia Pty (Ltd) in 1999 and is located in the south west of Namibia, adjacent to the NamibRand Nature Reserve and the Namib-Naukluft National Park. The Atlantic Ocean is 130 kms to the west, and it is 125 kms south-west from the village of Maltahöhe, the nearest place where basic supplies can be obtained. The property is 9 060 hectares in extent with the highest point being 1 579 meters and the lowest, 1 040 meters. The DDNR is 110 kms from the popular Sossusvlei / Sesriem complex and situated in the pro-Namib eco-zone which is characterised by episodic rainfall and highly variable temperatures. Average rainfall is cited as 80 mm per annum (Odendaal & Scott 2011).

Figure 1-1: Drifters Desert Nature Reserve

The Drifters Desert Lodge (DDL) and Drifters Desert Camp (DDC) are located on the DDNR. The reserve is off-grid with energy being supplied in-situ and water provided by pumping from underground streams. There is no natural standing water. DDNR is utilized exclusively for tourism and there is no other form of income. Being in the Namib Desert it is scenically spectacular and since Drifters purchased the title twelve years ago considerable investment has been made in returning what was previously a marginal sheep and cattle farm to its natural state. There are healthy herds of oryx, kudu and springbok as well as several endangered or protected animal and bird species such as lappet-faced vulture, Ruppels korhaan, genet, caracal, aardwolf, Cape fox, bat-eared fox, black-backed jackal, leopard, spotted hyena and the occasional cheetah.

Figure 1-2: Drifters Desert Camp

The DDC is used on two of the standard-departure Drifters itineraries: the 24-day Cape Town via Victoria Falls to Johannesburg tour (CV) and the shorter 12-day Namibia tour (NAM). The CV tour departs every Saturday from Cape Town and spends two nights of each week on the DDNR. The NAM tour departs from Windhoek every second week and also spends two nights on the reserve. The groups are completely independent and bring in all their own consumables such as wood, food and cooking gas (LPG). Facilities at the DDC include shaded camping sites for tents, a basic kitchen, male and female toilets and showers, and a rock plunge pool. Organised activities while in camp are a morning walk and a game drive.

The DDL is used by self-drive clients known as fully independent travellers (FITs). FITs are virtually always pre-booked clients who are on a tour of Namibia, generally in a rental vehicle. The facilities at the lodge include en-suite rooms, a swimming pool, a small bar, a fireplace for cold winter nights, and a kitchen for occasional self-catering guests and for use by the lodge.

Activities on the DDNR include nature walks and game drives and the main attractions are the landscape and the wildlife. Wildlife numbers can vary considerably depending on the season and consequent migratory patterns but the general landscape is always superb and thoroughly enjoyed by the guests.

Figure 1-3: Drifters Desert Lodge

1.4 Carbon neutrality at the DDNR

Land use changes reflect that farming in the Southern and Western steppe areas of the Namib is becoming more marginal and tourism is an increasingly important contributor to the economic well-being of people in the area (Reid, Macgregor, Sahl, & Stage, 2007a) and at a national level tourism in Namibia is second only to mining in terms of sectoral contribution to gross domestic product (Ministry of Environment and Tourism, 2011). However, tourism should ultimately aim to be sustainable from cradle to grave, thus research into the potential carbon neutrality of tourism is important to the industry itself at a local level, as well as for tourism policy at a national one. Whilst it is now widely recognised that the business-as-usual fossil fuel based economy is no longer tenable, change is expensive, and in the context of the DDNR there are fossil fuel systems in place that are durable and robust. These systems are likely to endure unless funding mechanisms are found to accelerate a transition to renewable energy technologies (RETs).

Looking to the clients the DDNR may be able to fund some of the cost of moving toward a less carbon intense system through the implementation of a voluntary carbon emission payment. If voluntary carbon offsets, otherwise known as voluntary emission reductions or VERs, can be used to accelerate change at the DDNR they could also potentially be used at corporate or country level to reduce the carbon intensity of larger operations.

Given the structure of the tourism industry in Namibia and the fact that the country is a net carbon sink (Ministry of Environment and Tourism, 2011) carbon-neutral tourism in Namibia is a real possibility, and since the tourism industry in Namibia relies more on individual product owners to market their own products than it does on country-wide marketing, it may be that carbon neutrality could be more effectively pursued on a local level (Jones, Plessis, & Thalwitzer, 2009). In the case of the DDNR there is no push for change at a shareholder level, but if it can be determined that there is a significant pull from clients it could become possible to validate a move toward a carbon-neutral economy.

Moreover, adapting and replacing the fossil fuel components of the energy systems at the DDNR will come at a price that cannot be wholly borne by the current balance sheet, thus, in order to fund part of the move to carbon neutrality, the feasibility of implementing a locally developed carbon offset programme was investigated.

With this in mind a two-pronged research approach was adopted. Firstly, the price and concept resistance levels of individual clients were tested with a willingness to pay (WTP) survey. 121 clients were asked to complete questionnaires which involved them affirming or denying a link between climate change and tourism, where after they were presented with a range of WTP choices. From the answers to these questionnaires an overall idea of WTP toward offsetting was obtained. The second phase of the research involved quantifying the energy usage of the reserve according to the International Standards Organisation (ISO) standard 14064-1 and calculating possible energy savings and payback periods that could be applied with the installation of less carbon-intense equipment - RETs. Demand side management and the introduction of operational efficiencies were also investigated, but to a limited extent.

To bring these two streams together an overall WTP figure was estimated and extrapolated over a one year period, as per the ISO protocol. The same exercise was performed for low-carbon technological interventions. RETs were then priced and the portion of the cost that the WTP could cover was calculated to obtain an idea of the extent a voluntary payment by the clients of the DDNR could contribute to moving the organisation toward carbon neutrality.

1.5 Synthesis of knowledge

In the review of extant literature and in order to understand tourism and its global footprint the vested interests of tourism companies in Namibia are discussed as well as their response to current emissions trading schemes.

A broader framework is then provided by detailing the current and possible future structure of energy supplies in Namibia before looking into current and potential initiatives to reduce fossil fuel dependency. The need for change is then clearly reinforced through a discussion on the effect of climate change on the Namibian landscape where domestic stock numbers are predicted to face a marked decline and wildlife numbers are also predicted to decline, but to a lesser extent than that of domestic stock, especially if open rangeland management practices can be pursued (H. Brown, 2009). The Namibian landscape is also shown to likely start suffering from a decline in aesthetic value due to decreased rainfall and unpredictable weather events (Turpie et al., 2010).

Measures to combat climate change are then investigated by examining the rise of carbon off-setting through various emissions trading schemes and the possibility of using carbon off-setting in a local context at the DDNR is discussed. In order to ascertain a ceiling of possible contributions to a carbon offset scheme the concept of willingness-to-pay is investigated and the methodology of quantifying the amount of GHG emissions that the DDNR has to account for is discussed.

Once the theoretical background to the study is fully investigated the quantification exercises are undertaken, results are collated, and a conclusion drawn about the viability of a local carbon offset scheme to effect changes on a local level.

2 Literature review

2.1 Tourism's global footprint and its relevance to Namibia

"Tourism is a social, cultural and economic phenomenon which entails the movement of people to countries or places outside their usual environment for personal or business/professional purposes" (UNWTO 2011b:1). Tourism is thus intrinsically linked to travel. During 2010 worldwide international tourism arrivals numbered around 935 million per annum (UNWTO 2011a) and while tourism statistics can be misleading it is staggering to consider that with a current global population of around seven billion people around 12% of these people travel for leisure. By 2020 international tourist arrivals are expected to reach 1.6 billion people per annum (UNWTO 2009).

The UNWTO has acknowledged that tourism is a vector for climate change and now accounts for 5% of global CO_2 emissions (UNWTO 2009) and if current tourism growth rates continue it will be responsible for 13% of global CO_2 emissions by 2035 (UNWTO 2009). Most of this increase can be attributed to growth in long-haul air travel with an over six-fold increase in air travel from benchmark 1990 levels by 2050 (IPCC 2000b). In the same period there have been unremarkable gains in airplane efficiency and there is still little prospect of a technological quick-fix. Airplanes are long-lived, normally over 50 years, and an industry wide study by the IPCC predicts that kerosene-type fuels are the only viable option for the future to 2050 (IPCC 2000b).

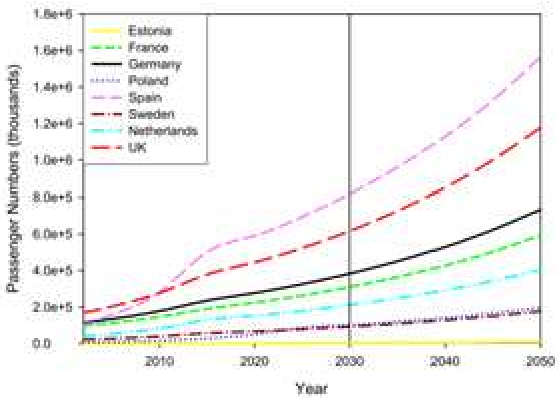

Figure 2-1: Forecast passenger number growth in EU aviation
(Bows, Upham & Anderson 2005)

Indeed, as figure 2.2 shows, with an aviation-business-as-usual approach, and if the European Union (EU) manages to adhere to emission-reduction targets, EU aviation emissions will constitute 80% of legal EU emissions by 2050 (Bows, Upham & Anderson 2005). Importantly, these emissions are for CO_2 alone and do not include the multiplier effect of irradiative warming from water vapour which may speculatively increase the warming effect somewhere around 2.7 times (Bows, Upham & Anderson 2005). Perhaps the reason that aviation related emissions remain out of the ambit of the legally-binding reduction targets of Kyoto is that for now there is simply nothing significant that can be done to reduce them, other than to cut back on flying.

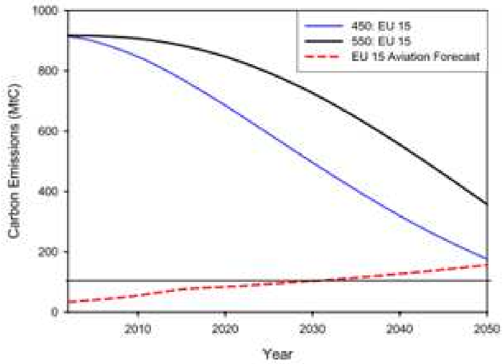

Figure 2-2: Contraction and convergence predictions for EU aviation (Bows, Upham & Anderson 2005)

Similar to the UNWTO, member companies of the World Travel and Tourism Council (WTTC), primarily a private sector organisation, have committed to cutting their 2005 emission levels by half by 2035 (UNWTO 2009), but, it seems that they have yet to formulate the 2005 baseline.

The strategy the UNWTO has adopted is somewhat gaunt - the UNWTO has decided to encourage airlines to halve their emission levels by 2050, as well as to encourage local communities to adopt mitigation and adaptation strategies (UNWTO 2009). These are broad and undefined goals that are reflective of institutional agendas - to safeguard tourism and long haul travel - which is often justified through continual references to the role tourism plays in uplifting the poor: "Tourism contributes to sustainable development, poverty reduction and the Millennium Development Goals. Any framework agreement should not disproportionately disadvantage those most dependent on tourism" (UNWTO 2009:4).

Jacqueline Asheeke is the ex-CEO of the Federation of Namibian Tourism Associations (FENATA) and, in a review of the Air Passenger Duty (APD) recently introduced in the United Kingdom (UK), Asheeke stated: "...green crusaders against air travel have salaried, air-conditioned-office jobs in some European, American, Australian or Asian company trading carbon and they are creating or adding to the hype against air travel that could damage eco-tourism destinations like Namibia" (Asheeke 2010).

Wilderness Safaris, one of the larger tourism operations in Namibia, states in its Annual Sustainability Report that the prevailing perception is that in order to reduce carbon emissions associated with travel, long-haul flights should be discouraged in favour of holidays closer to home (Wilderness Safaris, 2011). Wilderness considers this perception to be the most serious climate change related threat posed to its business: greater than the other risks considered in the report including insecure energy supplies, changes in water levels and changes in the distribution of wildlife (Wilderness Safaris, 2011). In response to this threat Wilderness Safaris states: "This is a superficial argument which overlooks the positive impacts on economies and conservation that result from long-haul travel for tourism to Africa. If such travel was to be discouraged, it would have serious negative consequences for both economic development and conservation in Africa (and other developing world regions). This dialogue must therefore be countered and corrected" (Wilderness Safaris 2011:29).

The Wilderness Safaris Annual Sustainability Report also states that it is investigating offset schemes (Wilderness Safaris, 2011) but the core of their (and FENATA's) narrative remains that attempts to regulate the emissions of long haul flights are hype and that perceptions need to be corrected because less tourism will negatively affect local economies. In the area of the DDNR, and in Namibia and the whole of the developing world, this may indeed be locally correct. With a wholesale move away from agriculture toward conservation[7] in the Pro-Namib area tourism is certainly a significant employer. However, the argument that long haul flights are necessary since they contribute to local economies and conservation is in itself superficial.

The European Union's Emission Trading System (EU ETS) was the first large emissions trading scheme in the world and covers 11 000 power plants and industrial sites in 30 countries (European Commission, 2012). As of 1 January 2012 the EU ETS was expanded to include aviation and all flights in and out of the 30 signatories to the EU ETS will be charged a carbon fee based on the full length of the flight (European Commission, 2012). The immediate effect will be minimal since each airline flying in EU airspace will have an emission allowance allocated and only once this allowance is exceeded they will have to pay for carbon used thereafter - a so-called cap and trade scheme: hit the cap, and start to trade, in carbon (European Commission, 2012). Thus flights originating in Windhoek and ending Europe or vice versa will hereafter have to pay a carbon fee based on the full length of the flight from the time the plane starts to move in its airport of origin.

But there is much international opposition to the EU scheme. In January 2012 the Chinese Air Transport Association announced their refusal to participate in or cooperate with the scheme and estimated that it would cost Chinese airlines US$ 123 million in the first year alone (Reuters, 2012). The International Air Transport Association (IATA) estimated that the initial cost of the EU ETS in 2012 could be EUR 900 million rising to EUR 2.8 billion in 2020 (International Air Transport Association, 2012). IATA and others challenged the EU ETS in court stating that the Chicago Convention, and international aviation agreement, prohibits taxes being levied on international airlines by third parties, but late in 2011 the Court of Justice of the European Union ruled in favour of the EU ETS (International Air Transport Association, 2012). The Federated Hospitality association of Southern Africa (FEDHASA) reported that South African Airways was complying with the scheme but have voiced their opposition to it since it is a unilateral imposition of taxation that affects airlines in other countries airspace, countries which will not necessarily benefit from the disbursement of these funds (Federation of Hospitality Associations of Southern Africa, 2012).

While true that tourism biased economies such as Namibia's rely on long-haul tourism's contribution, and added charges such as the APD in the UK and the EU ETS in Europe threaten to impact arrivals figures, in the context of climate change the APD and EU ETS and the effect that they may have on the number of people flying, and the consequent reduction in air travel related emissions could save the global economy more in terms of the direct cost of climate change adaptation and mitigation than the contribution that tourism makes to local economies. Local adaptation and mitigation costs could themselves outweigh the benefits derived from tourism and the very flights that now sustain local economies may contribute to their long term demise unless innovative ways to reduce the carbon intensity of travel are explored.

[7] Refer figure 2.11.

2.2 Energy in Namibia

2.2.1 Electricity

In order to understand the need for sustainability in a local context it is important to investigate the broader milieu of energy provision in Namibia. The Electricity Act of 2000 created the framework for the establishment of the Electricity Control Board (ECB) for the independent regulation of the electricity market, Independent Power Producers (IPPs) to augment NamPower's capacity, and Regional Electricity Distributers (REDs) to streamline electricity supply (Schmidt, 2009), effectively unbundling the supply, generation and distribution sides of power provision. The ECB now plays an important role in electricity policy in Namibia, three of the five proposed REDs are operational, and a framework has been created for the existence of IPPs (Schmidt, 2009) although there are at present no IPPs registered with NamPower (Shilamba, 2011a) since the continued low price of imported energy and resultant cost structuring by NamPower remains a disincentive for private enterprise.

2.2.2 Electricity: supply and demand

Namibia currently has an electricity generating capacity of 415MW which is seldom used fully due to the expense involved; generally Namibia supplies around half of the domestic electricity requirement (Aurecon Group, 2011). Peak demand in June of 2011, excluding the 96MW demand requirement at the Skorpion Zinc Mine in the south of Namibia which is supplied by the South African utility Eskom via a 'back to back agreement' with NamPower (Fitch Ratings, 2009), was 511MW (Aurecon Group, 2011). The balance is imported from South Africa, Zimbabwe, Mozambique, Zambia and the Democratic Republic of Congo (Shilamba, 2011b).

The White Paper on Electricity Policy (WPEP) of 1998 recommended 75% self-sufficiency in electricity supply by 2010, an objective which clearly has yet to be met (Schmidt, 2009). Part of the reason for the inertia was the guaranteed supply of cheap electricity from the South African power utility Eskom, but since the electricity supply crises in South Africa of 2007/8 the traditional oversupply of cheap electricity in that country has come to an end and the agreement with NamPower has been renegotiated (Schmidt, 2009). A second supply constraint is the low capacity of the transmission lines between the North and East of South Africa, the location of most of the South African generating capacity, and the Western Cape where the supply line from South Africa to Namibia is located. A substantial portion of the supply to Namibia was traditionally sourced from the Koeberg power station in the Western Cape and this capacity has subsequently been redirected internally within South Africa (Electricity Control Board, 2006).

Namibia's own installed capacity includes the 24MW Paratus heavy oil station in Walvis Bay, the 120MW Von Eck coal fired Power Station in Windhoek, and the 249MW Ruacana Hydro plant on the Kunene river on the northern border of Namibia (Von Oertzen 2010; MET 2011). The Von Eck and Paratus stations are expensive to run, more expensive per kilowatt than the on-sale price to larger customers[8], and during the 2007/8 supply crises Nampower incurred significant losses through utilising these power sources: losses which provided impetus to upgrading internal capacity and addressing supply constraints (Von Oertzen, 2010). Further

[8] Von Eck: 60c/kWh; Paratus: 79c/kWh; Ruacana: 6c/kWh (Electricity Control Board, 2006).

complicating matters is the fact that the Ruacana Hydroelectric plant is a run-of-river plant with no upstream holding facility, making electricity generation unpredictable, especially in the context of falling rainfall figures in the Kunene river catchment area in southern Angola (van den Bosch, 2011).

Partly as a bridging measure to address supply constraints NamPower invested in upgrading the Hwange coal-fired power station in Zimbabwe and in return secured 150MW of electricity production per year for five years starting in 2008, but transmission losses through South Africa and Botswana (Schmidt, 2009) reduce the efficiency of supply.

Other investments by NamPower include the 600MW final capacity HVDC lines via the Caprivi corridor to Zambia and Zimbabwe (von Oertzen in Schmidt 2009) to streamline power imports and small and medium capacity investments including a 22MW peak supply diesel-fired station at Walvis Bay, Anixas, installation of a fourth and last 95MW turbine at Ruacana, and a combined 105MW run-of-river installation on the Orange River (Shilamba in Schmidt 2009). Large capacity projects include the development of the Kudu Gas fields along the coastline which are envisaged to supply a gas-fired station in Walvis Bay or Oranjemund, the development of the Baynes Hydroelectric scheme on the Kunene river, and a large coal-fired plant at Walvis Bay (Shilamba in Schmidt 2009).

Existing capacity				
Paratus		Heavy oil	Walvis Bay	24MW
Von Eck		coal	Windhoek	120MW
Ruacana		hydro	Ruacana	249MW
Anixas		Diesel	Walvis Bay	22MW
Total installed capacity				415MW
Peak demand June 2011 (excluding 96MW of Skorpion Zinc in the south of Namibia)				511MW
Implementation stage				
Ruacana	Mar-12	hydro	Ruacana	95MW
Future projects				
Orange River		Hydro	Orange River	105MW
Kudu		Gas	Kudu	800MW
Erongo	2015 - 2018	Coal	Walvis Bay / Arandis	400 - 800MW
Baynes		hydro	Kunene River	500MW

Table 2-1: Electricity supply in Namibia

Table 2-1 above shows that at a current theoretical maximum Namibia could produce 60% of electricity demand but in reality, with the Paratus and Von Eck stations being more expensive to run than it is to buy imported power, during 2009 Nampower was only able to supply 40% of local demand (Shilamba, 2011a) and has on occasion imported up to 80% of demand (Aurecon Group, 2011). With the Ruacana fourth turbine nearing completion in early 2012 Namibia's 'efficient' generating capacity will jump by around 25%, but growth in electricity demand during 2012 is projected to be around 4.6% and additional base-load generating capacity is still at a minimum six years away (Aurecon Group, 2011), by which time local demand will still exceed local supply by a sizeable portion. It can thus be seen that Namibia already has a serious shortage of internal generating capacity and it will become quite severe in the short to medium term.

2.2.3 Future fossil fuel mega-projects

In terms of long term developable electricity supply Namibia has abundant off-shore gas with the Kudu gas field off the South East coastline having reserves that could operate a 800MW combined-cycle gas power plant for more than 20 years (Schmidt, 2009). The Kudu project nonetheless faces significant challenges to development: it is 170km offshore and at a depth of 4.5km (Schmidt, 2009), and it is far from areas of significant electricity consumption.

In 2005, after feasibility studies and environmental impact assessments, a license was issued for the development of a closed-cycle generation facility at Oranjemund, but license holders Tullow Oil plc and Eskom could not come to an agreement with Nampower on pricing and currencies so the project stalled (Schmidt, 2009). Currently Tullow and its Japanese and Russian partners, Itochu Corp of Japan and Russia's OAO Gazpromban (Shiryaevskaya & Gismatullin, 2011), are finalising the gas sale agreement which still follows the model of a single gas supply to a single gas power generating station (Shiryaevskaya & Gismatullin, 2011).

The Kudu Power Station is proposed to be a public-private partnership where NamPower will hold 51% equity in the power station and private investors will bid for the balance (NamPower, 2011). Half of the proposed 800MW will be retained for local use and the remainder is to be sold into the regional grid (NamPower, 2011). The Managing Director of Nampower, Mr Shilamba, is holding out hope that pricing models and declarations of intent will be finalised by mid 2012 (Shilamba, 2011b) but the Kudu project has been on-again off-again for so long now, approximately 13 years (Kapenda, 2011), that further delays seem inevitable.

Nonetheless Namibia's Second National Communication to the UNFCCC on reducing the carbon intensity of the Namibian economy holds out hope that the development of the Kudu gas field will be an enabling factor in the conversion of the Namibian transport fleet of vehicles from petrol to LPG, a less carbon intense fuel (Ministry of Environment and Tourism, 2011). The report cites that the conversion of over 170 000 petrol vehicles on Namibian roads would result in a 20% reduction in CO_2 production, and save the fiscus N$278 million in foreign exchange required for importing refined petrol from South Africa (Ministry of Environment and Tourism, 2011). Developing the Kudu field will thus potentially enable the Namibian economy to save on foreign exchange payments, become less energy-intense, and become more emissions-friendly, but in reality the conversion of 170 000 vehicles is somewhat far-fetched. There is currently a single business in Windhoek that converts petrol vehicles to LPG, Autogas Namibia, which is actually more of an LPG distributor than a vehicle convertor, and Autogas uses the potential environmental benefit of LPG, especially in the context of transport, as an argument to ensure the continued existence of an LPG subsidy from the Ministry of Mines and Energy (MME) (personal communication, Mendonca, A., 15 October 2011). Currently most of the Autogas vehicle conversions are high-pressure LPG conversions that massively increase vehicle performance, not low-pressure LPG conversions that potentially save on fuel costs and vehicle maintenance (personal communication, Mendonca, A., 15 October 2011).

In another medium term measure to relieve the pressure on power supplies the Ministry of Mines and Energy (MME) is investigating the construction of a coal fired power plant at Walvis Bay or Arandis. The scoping environmental impact assessment was completed in 2008 and justified the use of coal as being a regionally abundant and cost effective resource that will provide reliable base load power (Ministry of Mines and Energy, 2011a). Arguments in favour of the coastal location and the choice of technology is that cooling resources are close by (sea water) and that shipping directly to the port of Walvis Bay without having to trans-ship over hundreds of kilometres would be cheaper than supplying an inland station such as Windhoek (Shilamba in Schmidt 2009). At the end of 2011 the environmental impact assessment was updated and the preferred site was considered to be east of the town of Arandis, close to major mining customers and in an area in which it will have a lower environmental impact (Aurecon Group 2011, Shilamba 2011a). It seems that the political will is there to make the Erongo Power Station happen sooner rather than later with possible dates of implementation being proposed for as early as 2015 (Shilamba, 2011b).

With regard to liquid fuels, during the middle of 2011 the Namibian press reported on comments made by the Minister of Mines and Energy, Minister Isak Katali, of a potential ‘herd of elephants’ being found in oil exploration activities (Fin 24, 2011). Fin 24.com reported the Minister saying there were an estimated eleven billion barrels of reserves off the Namibian coast with production expected within four years, which would put Namibia in the same league as Angola with its estimated 14 billion barrels of reserves (Fin 24, 2011). Minister Katali’s statement to the Namibian parliament on the 5th of June 2011 detailed Enigma Oil and Gas as having 4 billion barrels of reserves and HRT Oil and Gas of Brazil as having a potential 5.2 billion barrels of reserves and US$ 300 million in funds allocated to explore its licensed areas off the coast of Namibia, with an expected 6 to 8 wells being drilled in the next 18 months (Ministry of Mines and Energy, 2011b). In December 2011 Minister Katali clarified his outlook by stating that the exploration companies had not actually found any oil and were basing their predictions on reserves by looking at the similarly formed off-shore geology off the north east coast of Brazil where substantial reserves are being exploited (Matali, 2011). The reality is that there is a huge difference between ‘estimated’ and ‘confirmed’ and when and if oil deposits are confirmed there is a lengthy process between exploration, discovery and utilisation, especially when investigating the establishment of a local refinery for domestic distribution and consumption.

2.2.4 Demand side management

In 2006 the ECB completed an extensive study on demand management options in Namibia (Electricity Control Board, 2006) and demand management in Namibia was then driven by an implementation plan that included time-of-use tariffs, a compact fluorescent light rollout program, the ripple control of geysers, load shifting, education campaigns and the subsidisation of the solar water heater industry (Electricity Control Board, 2006). Adding further impetus to the renewable industry was a 2008 cabinet directive requiring all new government buildings to be supplied with solar water heaters instead of traditional electric geysers (Schmidt, 2009). However in his annual address to the public at the end of 2011 the MD of Nampower made scant reference to demand management preferring to dwell on the large plug-in solutions to the constrained power supply (NamPower, 2011). Demand management in Namibia appears to be on the back burner and a 'large corporation' mentality seems to be the order of the day at NamPower where headline projects are used to augment power supply without a focussed attempt to seriously investigate and implement demand management options.

2.2.5 Renewable energy technology

Figures from the MME reflect that around 33% of Namibians have access to electricity, with only 10% penetration in rural areas. Of 2 855 rural settlements, 2 400 are not electrified (Heita, 2006). Of these settlements, 131, comprising 27 000 households, are considered off-grid and will not benefit from electrification for a minimum of 20 years: the framework for rural electrification is provided by the 20 year Rural Electrification Master Plan of 2005 (Heita, 2006). As a result of the widely dispersed nature of the Namibian population and the resultant difficulty in providing access to electricity, off-grid electrification and the promotion of RETs are being driven by a combination of private enterprise, NamPower, the ECB and the MME and considering the practical, financial and logistical difficulties involved in rural electrification in some instances the use of RETs for off-grid electrification is an attractive option for the state.

In 1996 the Solar Revolving Fund (SRF) was set up by the MME as a means of providing access to renewable energy to especially rural but also urban households through providing low interest loans to Namibian citizens for the installation of RETs and the SRF has subsequently become an important component of the Rural Electrification Master Plan (Ministry of Mines and Energy, 2011c). Utilisation levels of the SRF were initially low with an average of 80 applications per annum for finance from the period 1996 to 2004 but due to a number of donor funded initiatives promoting access to RETs the number of loan applications in 2005 rose to 300 (Heita, 2006). Up until 2010 the SRF was administered by private and parastatal agencies, but the MME, under Minister Katali, took over administration of the fund from April 2011 (The Economist, 2011) and the SRF basket has subsequently been expanded to include solar cookers, LPG stoves and lighting devices and these are funded as a packaged deal as 'solar home systems' (Ministry of Mines and Energy, 2011c).

Loans are extended, dependent on credit worthiness, on the basis of quotes from approved suppliers registered with the MME for amounts of up to N$ 50 000 for solar water pumps, N$ 35 000 for solar home systems, and N$ 30 000 for solar water heaters. Loan amounts may not exceed more than 30% of the applicant's gross income and are granted for periods of up to five years at a fixed annual interest rate of 5% (Ministry of Mines and Energy, 2011c). The MME appears to administer the fund efficiently: "We work on a regular basis with MME and are generally very satisfied with the feedback we get. Payment of completed installations is without hassles and within the same month most of the time" (personal communication, Rehmer, M., 20 January 2012).

The Renewable Energy and Energy Efficiency Institute (REEEI) is based at the Polytechnic of Namibia with funding from the MME and the Global Environmental Fund (GEF) via the implementing agency, the United Nations Development Program (UNDP). The UNDP administers the funding via the Namibia Renewable Energy Program or NAMREP which aims to address administrative barriers to the implementation of RETs in Namibia (Renewable Energy and Energy Efficiency Institute, 2011a). According to the REEEI, as per figure 2-3 below, countrywide PV and photovoltaic pump (PVP) capacity installed during the 2008 year was around 300kW with approximately 4000m² of solar water heaters being installed as well (Renewable Energy and Energy Efficiency Institute, 2011a).

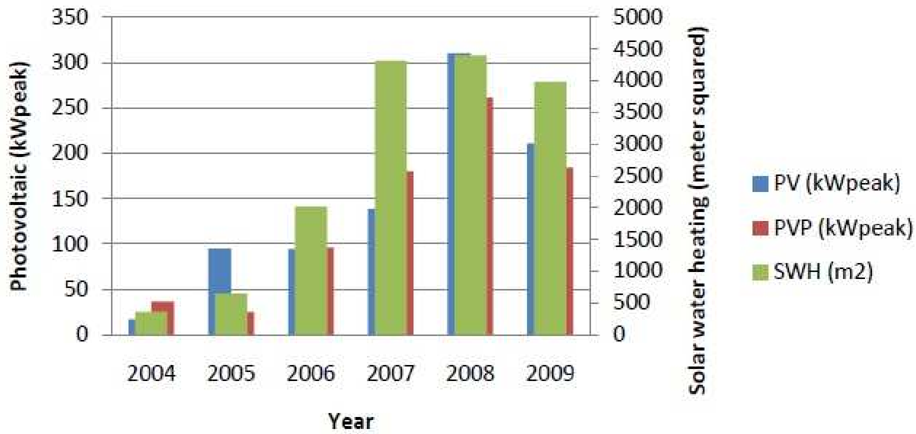

Figure 2-3: Solar technology installed per year in Namibia
(Renewable Energy and Energy Efficiency Institute, 2011a)

However, considering that PVP works best at a head of below 150m and with relatively low water delivery, not more than 15m³ per day (Heita, 2006), and that there are an estimated 15 700 boreholes in Namibia that fulfil this criteria it seems incongruous that of the 8 500 water points provisioned by the Namibian Ministry of Agriculture, Water Affairs and Rural Development less than 1% are supplied via a PVP system (Heita, 2006).

Moreover, from the perspective of the DDNR, access to the SRF would be complicated and probably unlikely. The DDNR property is held in the name of a company, Greenfire Investments Namibia PTY LTD, and the four shareholders are South African. The SRF specifically states that loans will be provided to applicants that are Namibian citizens and the loan application makes no provision for companies to be able to apply for funding (Ministry of Mines and Energy, 2011c). The focus of the SRF is firmly on facilitating access to RETs as a part of the Rural Electrification Master Plan of 2005 and while the DDNR is certainly off the grid, from a commercial point of view it is unlikely to be considered truly rural. A more appropriate way of access the SRF may be through staff of the DDNR applying in their personal capacity for a loan to have their own accommodation electrified but this would presuppose a degree of security of tenure which they do not necessarily have.

2.2.6 Renewable energy technology: headline projects

Sizeable donor funded RET projects include amongst others a diesel / solar hybrid system in Tsumkwe (Tsumkwe Energy) and an invader-bush project near Otavi, both initiated by the Desert Research Foundation of Namibia (DRFN). The projects received seed funding from the European Union (Desert Research Foundation of Namibia, 2011), and the Tsumkwe Energy project also benefitted from N$5 million in funding from NamPower (Schmidt 2009). Since the cost of installing transmission lines to Tsumkwe would have been in the region of N$80 million NamPower views the provision of an alternative energy source as being cost-effective: "You have to remember that these are just a few houses, not major industries, so the return on investment of connecting Tsumkwe to the grid would probably not be realised in the next 100 years" (Shilamba in Schmidt 2009b:29). Through the addition of solar energy, a 2 000kWh battery storage capacity, the upgrading of the switch gear and transmission lines, as well as demand side management (DSM) through education and the introduction of fuel efficient technologies, it is hoped that the running time of the Tsumkwe diesel generator will be reduced from 8 760 hours to an optimistic 400 hours per annum (Desert Research Foundation of Namibia, 2011), as per diagram 2.4 below.

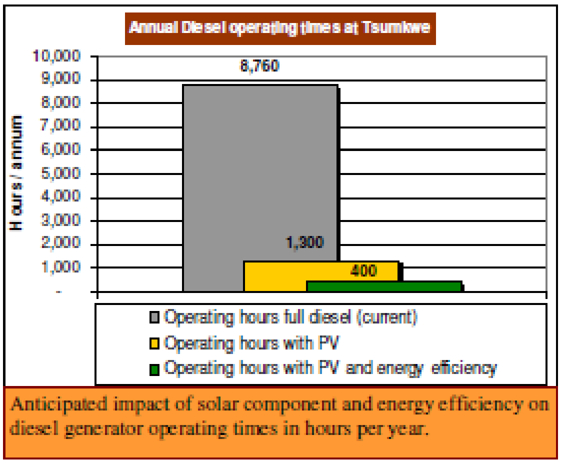

Figure 2-4: Potential reduction in operating times of diesel plant at Tsumkwe (Desert Research Foundation of Namibia, 2011)

Due to poor grazing practices and the suppression of natural fire regimes Namibia has a severe bush encroachment problem in the northern parts of the country, which makes the use of wood chips as a fuel source a possibility. Total woody biomass use in Namibia is 1.357 million cubic meters per annum (cubes p/a) and with a sustainable yield of 19.18 million cubes p/a use is only 7% of yield, resulting in a net accumulation of 17.8 million cubes p/a of woody biomass (Ministry of Environment and Tourism, 2011). Part of the reason for this increase is the previously noted reduction in wildfires over the last century. Wildfires burn and kill young trees and bushes which take longer to regenerate than grasses. A second contributor, the overgrazing of grasses, has meant reduced competition for bushes and trees and led to further bush encroachment. Another perhaps less obvious reason for the bush encroachment may be that since plants absorb CO_2 as a part of the photosynthetic process increased levels of CO_2 means that they may be growing at a faster rate, although this has not been empirically verified in Namibia (personal communication, Murphy, M., 10 October 2011).

The CBEND - Combating Bush Encroachment for Namibia's Development - wood gasifier in Otavi was inaugurated in September 2010. It has a capacity of 250kW and will feed electricity directly into the national grid once it is registered with the ECB as an IPP (Von Oertzen, 2010), but obstacles remain to the effective grid integration of the gasifier. Detlof Von Oertzen, a previous Executive Director of the DRFN, estimated a unit production cost of N$1.33 p/kWh for the CBEND project (Von Oertzen, 2010) which is considerably more than the cost of an imported kWh for Nampower and certainly not even comparable to the approximately 6c/kWh of the Ruacana hydro scheme (Schmidt, 2009).

In the tourism arena some commercial enterprises are moving from fossil-fuel based systems towards the use of RETs. NamibRand Safaris, the owner of the Wolwedans group of lodges close to the DDNR, recently installed a solar array that is set to reduce generator operating time from eight hours to three hours per day, a reduction in the order of 60%. The installation is part funded by the Development Bank of Namibia and is viewed as a pilot project to gauge the viability of the RET technology. The estimated payback period of the investment is five years (personal communication, Bruckner, S., 29 September 2011).

Figure 2-5: Wolwedans solar array

As yet there are no feed-in tariffs or power purchase agreements available to RET providers in Namibia and as such the legislative framework remains somewhat insecure and commercial RET suppliers (as opposed to the non-commercial donor funded projects at Tsumkwe and Otavi) will no doubt wait until firm guidelines are promulgated before the implementation of RET projects. Nonetheless there are a number of promising projects in the pipeline. Despite Namibia having an abundant direct solar resource it seems as if the modular nature of wind power projects makes them closest to becoming formal grid connected independent electricity providers.

In September 2009 AllAfrica.com reported that Innowind, a French based wind power producer with South African and Namibian registered companies, applied to the ECB for the establishment of a phase-in 300MW wind farm on a site to the south of Walvis Bay (All Africa.com, 2009). The application proposed the installation of 3MW turbines over four phases with the first phase scheduled for completion in 2011 (All Africa.com, 2009). Innowind list the Walvis Bay project as being one of several projects it is pursuing in the sub-region which contribute to 600MW worth of possible future installed capacity (Innowind, 2012) in South Africa and Namibia. The wind farm has not yet been developed but it remains one of the two wind farms that are close to being initiated with a firm 50MW being looked into for IPP status with the ECB (Shilamba, 2011b). At this stage a constraint to the development of the Innowind project is the Kuiseb substation and current plans to upgrade this substation will have to be implemented before the wind generators can be constructed (Shilamba, 2011b).

The Diaz Power Wind Energy project at Luderitz has been in the pipeline for several years as a joint venture between Sojitz Corporation of Japan, which will provide financial expertise and coordinate the project, the Korean Midland Power Company, which is to supply technical ability, and the United Africa Group, based in Windhoek, Namibia (United Africa Group, 2012). Initial capital cost of the project is projected at USD 150 million with phase one installed capacity of 44MW with operations expected to start in 2013 (United Africa Group, 2012). The ECB is investigating registering Diaz Power as an IPP during the course of 2012 (Shilamba, 2011b).

Through funding obtained from the GEF the REEEI recently issued a Request for Proposals to conduct a pre-feasibility study on the establishment of a pre-commercial concentrated solar plant (CSP) in Namibia (Renewable Energy and Energy Efficiency Institute, 2011b). The pre-feasibility study aims more to create a situation where technology transfer is apparent and Namibia builds a knowledge base on CSP plants than being directed toward creating a nascent CSP industry and a detailed solar resource base and the subsequent ideal location for CSP plants is part of the tender (Renewable Energy and Energy Efficiency Institute, 2011b). Thorough mapping of the solar resource in Namibia will be crucial to the future design, location and implementation of solar photovoltaic and CSP plants.

When studying the Namibia RET landscape it becomes clear that while there is no doubt that RET resources are abundant there are only piecemeal moves toward the use of RETs and without a legislated renewable energy feed-in tariff or some other form of subsidy renewable energy generated electricity will remain elusive since at this stage the only real projects are donor funded and commercial scale RETs are still in the planning stages.

2.2.7 Sequestration

One of the consequences of Namibia’s dependence on non-sovereign electricity is that the country is a net carbon sink since with somewhere around 50% of the electricity used being imported the GHG debt associated with electricity is effectively exported to the producer. Nonetheless the 2011 Namibian Second National Communication to the UNFCCC reported that the energy and agricultural sectors emitted 2 200 000 tonnes and 6 783 000 tonnes of CO_{2e} respectively (Ministry of Environment and Tourism, 2011). However, the land-use change and forestry sector collectively sequestered 10 560 000 tonnes of CO_{2e} (Ministry of Environment and Tourism, 2011) thus making Namibia a net carbon sink.

In the energy sector transport is the most significant contributor to national GHG emissions with 1 025 000 tonnes CO_{2e} per annum, around 50% of total emissions from this sector (Ministry of Environment and Tourism, 2011). In the land use and forestry sector the major contribution to the sequestering of emissions is the extensive bush encroachment occurring across the country: “this anthropogenic sink brought about by land use practices is estimated to occur over an area of approximately 26 million hectares” (Ministry of Environment and Tourism 2011:92).

In a more local context and with the DDNR in mind a dissertation on net carbon stocks in the semi-desert Serowe area in Botswana, an area with a more diverse species composition and higher annual rainfall of 300mm (Namayanga, 2002) than the Pro-Namib area, but nonetheless having dominant stands of *Acacia erioloba* - the dominant tree species at the DDNR, Namayanga found that there was approximately 752 000 tonnes of carbon sequestered above ground over 244 048 hectares: around three tons per hectare (Namayanga, 2002). If the Pro-

Namib ecosystem could sequester one quarter of the carbon sequestered in the Serowe area this would result in around 0.75 tonnes per hectare sequestered and since the DDNR is 9060 hectares in extent a potential 6 800 tonnes of carbon may be sequestered above ground on the DDNR. And when considering that *Acacia erioloba* saplings 5cm high have roots of around 1.5m long and saplings 25cm high have been found to have roots up to 3m long (Department of Water Affairs and Forestry, 2003) it becomes obvious that a mature tree would certainly have much more potential to sequester carbon underground than above it.

In terms of the ISO reporting standard for the measurement of GHG emissions of carbon the defined operation, in this case the DDNR, can make use of carbon sinks in order to quantify its net carbon balance, but it needs to made clear that the total amount of carbon sequestered in the DDNR does not equal the carbon sink potential. Carbon sink potential is a function of the rate at which carbon dioxide is absorbed by the vegetation and captured as woody biomass, not the sum total of available biomass. In order to determine the extent of the carbon sink the ability of *Acacia erioloba* to 'fix' carbon would have to be quantified and there are as yet no studies that have determined the rate of carbon fixing in the pro-Namib area.

Rattan Lal of the Carbon Management and Sequestration Centre of Ohio State University conducted research on the ability of arid ecosystems to sequestrate carbon and concluded that the maintenance and improvement of soil organic carbon in dry areas is an integral part of the global management of carbon. Arid ecosystems make up 47.2% of the global land surface area and are vassals for 15.5% of the 241 billion tonnes of global soil organic carbon, this despite desertification already having resulted in the loss of 20 to 30 billion tonnes of organic soil carbon (Lal, 2004). Lal contends that judicious range and soil management in drylands can result in the resequestration of one billion tonnes of organic soil carbon annually, sequestration potential that could have relevance for the Kyoto Protocol (Lal, 2004). If Namibia could register dryland soil carbon sequestration under the UNFCCC it could potentially benefit, but considering soil carbon is not yet a form of carbon sink recognised by the Kyoto and that sequestration figures are not available for Namibia dryland soil carbon, soil sequestration, while significant, is not going to be of benefit to Namibia in the medium term.

Namibia may be somewhat unique in that the dispersed and low population means that the rate at which deforestation occurs is slower or nearly the same as the rate of bush encroachment which makes the registration of forestry based carbon reduction projects under the CDM of Kyoto problematic since savings derived from sequestration are minimal. Once the onerous administrative and reporting burden of CDM projects is added to possibly marginal gains in offsets the registration of CDM forestry schemes in Namibia becomes unattractive.

It is clear that under the present emissions trading framework Namibia will be unlikely to benefit from certified reductions that are traded under the auspices of the CDM of Kyoto. Thus despite the fact that is has an obligation to reduce its share of global GHG outputs it is likely that the national focus will be more on adaptation due to vulnerability to climate change than it will be on mitigation.

2.3 Tourism, land use and climate change in Namibia

As can be seen in table 2.2 tourism arrivals in Namibia have grown exponentially from 254 978 in 1993 to 980 178 at the end of 2009 (Namibian Tourism Board, 2011). By 2016 tourism's proportion of the Namibian GDP is predicted to rise to 26% (Davidson 2009).

Tourist arrivals 1993 (independence from South Africa was achieved in 1990)	254 978
Tourist arrivals 2008	931 111
Tourist arrivals 2009	980 178
Increase in arrivals 2008 - 2009	5.2%
Increase in arrivals 2007 - 2008	11.4%
Tourism contribution to GDP in 2006	14.2% [9]
Total registered tourism businesses, end 2008	2 962

Table 2-2: Namibian tourism figures
(Namibian Tourism Board, 2011)

On reviewing available literature Hannah Reid of the International Institute for Environment and Development proposed the effect of climate change on Namibian GDP to be very significant for rural agriculturalists and less so for tourism. Rural areas are where 67% of Namibians live and their well-being is intrinsically linked to the health of the eco-systems in which they survive (Government of Namibia, 2011). Dr Chris Brown of the Namibia Nature Foundation estimated that in the Nama Karoo, an arid biome in the south of Namibia, a 20% reduction in mean annual rainfall would translate into a reduction in carrying capacity of around 2kg per hectare which was equated to a loss in meat productivity of N$18/ha at 2007 prices (C. Brown, in Reid, Macgregor, Sahl & Stage 2007b).The table 2-3 below illustrates the vulnerability of the agricultural value chain when compared to that of the tourism sector.

Values	Current GDP contribution (%)	Changes expected due to climate change (%)	Effect on GDP (millions N$)	Confidence in range of change
Use values:				
Cereal production	0.5	Decrease (10-20)	-16 to -32	Low to medium
Crop production	1	Decrease (10-20)	-32 to -65	Low to medium
Livestock production	4	Decrease (20-50)	-264 to -660	Medium
Traditional agriculture	1.5	Decrease (40-80)	-197 to -395	Medium to high
Fishing	6	Increase(30)/decrease(50)	0 to -990	Low
Tourism	2.3	Increase/decrease	-	Low
Forests	+ *	Unchanged	0	Low
Non-use value	+ *	Decrease	-	Low
Total value			-509 to -2142	

Table 2-3: Changes in Namibian GDP contribution by key economic sectors
(Reid, Macgregor, Sahl, & Stage, 2007b)

[9] The figure cited uses a very broad definition that includes all tourism and possible tourism related enterprises and spin-offs. Turpie et al. calculate the direct contribution of state protected area tourists to be 2.1% of gross domestic product (GDP) (Turpie et al., 2010) and with the multiplier effect this increases to 3.5%.

In 2009 Helen Brown studied the impact of climate change on commercial agriculture and wildlife farming in Namibia. Brown analysed temperature data from Windhoek over a 50 year period from 1950 to 2000 and found that there was an annual 0.023℃ increase in temperature (H. Brown, 2009), equating to around 0.2℃ per decade. Research on climate change in Namibia was also conducted by a team of scientists from the South African National Biodiversity Institute (SANBI) who collated information from 15 weather stations in southern and central Namibia and the Northern Cape of South Africa and found that 53% of stations showed a significant decadal increase in temperatures with none showing a decline. On average across all stations the mean decadal increase was 0.2℃ which is three times the global mean increase for the corresponding time period (Midgley et al. 2005; Dirkx et al. 2008). Water balance, a combination of temperature and rainfall figures that measures the amount of water available to plants, showed a significant decrease in 33% of weather stations, with none showing an increase (Midgley et al., 2005).

The SANBI study also found a direct link between the temperature increase and the decrease in water availability with the shift in distribution of a signature plant species in Namibia – the *Aloe dichotoma*. This Aloe has a wide distribution, from the Northern Cape to South Central Namibia, over a wide longitudinal spatiality with a consequent 200 000km^2 range and, importantly, it is long-lived – around 200 years (Midgley et al., 2005). 54 Sites of dense *Aloe dichotoma* stands were studied and mortality rates of 2% to 71% were found with increases in mortality correlating to lower altitude and higher latitudinal sites. There was also a correlation between mortality and populations within 100kms of weather stations that indicated decreased water balance and thus reduced water availability (Midgley et al., 2005). Thus both temperature and water availability play a critical role in the spatial distribution of this indicator species which is already being significantly impacted on by recently accelerating climate change. This is relevant because it reveals that the Namibian landscape will change significantly in the next century and will thus impact the landscape aspect of the Namibian tourism product.

Helen Brown used the same climate projections and IPCC scenario as the Midgley et al. team from SANBI used - the Hadley Centre HADCM3 model and the IPCC A2 storyline - to make predictions through regression analysis on the future viability of different farming practices, including wildlife farming, of which a significant portion is for trophy hunting and her study identified three factors as having a significant impact on income - rainfall, distance from Windhoek (and the subsequent transport costs for livestock and meat products), and land use (H. Brown, 2009). Rainfall had a direct correlation with income per hectare, with a 1.36% decrease in income per hectare for every 1% decrease in annual rainfall (H. Brown, 2009). This indicates that agriculture will be sensitive to an accelerated change in climate and domestic stock, being highly water dependant, will be affected more than wildlife.

When looking at this in a local context, the DDNR is situated adjacent to the NamibRand Nature Reserve and figures from this reserve indicate that wildlife responds quickly to an overall reduction in rainfall, despite the presence of artificially provisioned water (Scott, Scott & Odendaal 2010) as illustrated in figures 2.7 and 2.8 on the following page.

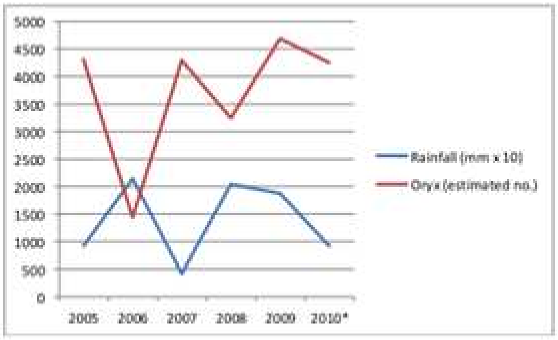

Figure 2-6: Estimated number of Oryx on NamibRand Nature Reserve correlated to rainfall (Scott, Scott & Odendaal 2010)

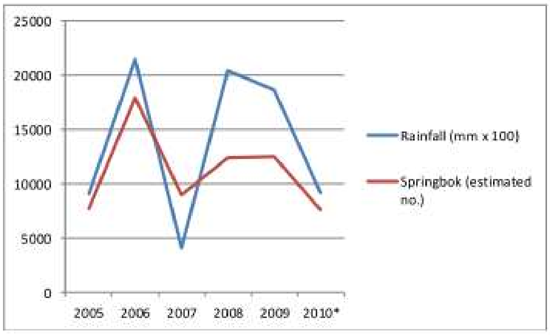

Figure 2-7: Estimated number of Springbok on NamibRand Nature Reserve correlated to rainfall (Scott, Scott & Odendaal 2010)

Clearly Oryx display a delayed response to changes in rainfall patterns but Springbok respond immediately. The total biomass of the NamibRand Nature Reserve increased by 23% from June 2005 to June 2009: from 9.0 kg/ha to 11.1 kg/ha due to a period of good rainfall (Scott, Scott & Odendaal 2010). With a decrease in rainfall in 2010, biomass immediately dropped 23% back to 9.0kg/ha. Range management is the key here. In areas of wildlife viewing species must be able to migrate to suitable habitat to ensure the long-term sustainability of populations and stakeholders thus need to form collaborative management systems based on open landscapes to: “help landowners cope with the increases in drought and rainfall variability expected with climate change” (C. Brown, in Reid, Macgregor, Sahl & Stage 2007b:21).

Under current price regimes trophy hunting and wildlife viewing are proving able to return more revenue per hectare than meat production, with revenue per hectare on stock farms being 42% lower than on farms used for trophy hunting (H. Brown, 2009). Helen Brown discovered that there was a direct correlation between an increase in rainfall per hectare and an increase in revenue but the rate of increase in revenue for trophy hunting was greater than the rate of increase for livestock farming, as per the following diagram (H. Brown, 2009).

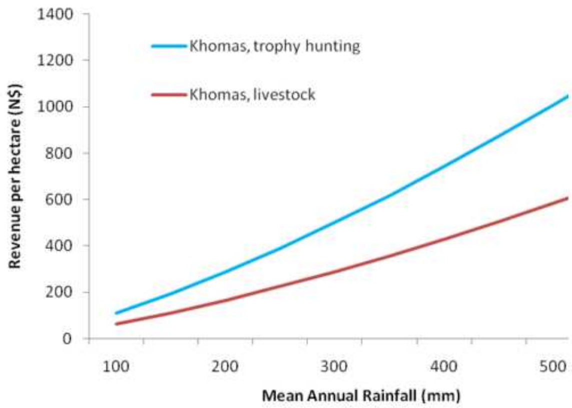

Figure 2-8: Revenue per ha increase with an increase in rainfall
(H. Brown, 2009)

It would thus not be unreasonable to argue that adapted range management of domestic stock would increase revenues per hectare and thus improve agriculture's long term viability profile: the essence of the solution, against the backdrop of an increasing temperature regime and variable rainfall, is that the effective management of rangeland is the key to adaptation and mitigation. Personal experience indicates that the opening up of rangeland is seldom possible. The DDNR is in a nature area where fences are clearly severely detrimental and cause much suffering to wildlife populations with regular very unpleasant fence-related deaths. None of the owners of the seven adjacent conservation-based properties are dependent on these properties for an income. While all landowners agree in principle that removing fences will benefit the management of the area, in the last twelve years of conservation only two of the five landowners have actually done so. It also seems highly unlikely in the short to medium term that agriculture based properties will remove fences and undertake joint management of livestock.

Up until 2010 there were no studies in Namibia that evaluated the potential impact of climate change on tourism and available literature reflected divergent views. Some authors were of the opinion that all tourism would suffer through the reduced appeal of the landscape and presumably lower wildlife numbers (van den Bosch 2011; Reid, Macgregor, Sahl & Stage 2007a; MET 2011) and others believed that long-haul tourism was more likely to suffer because of the introduction of taxes and penalties on long-haul flights and frequent fliers (van den Bosch, 2011; Asheeke, 2010; MET 2011). In terms of the effect of climate change in-country Helen Brown's study indicates that tourism, and especially trophy hunting, would be the beneficiary of a switch from meat production toward tourism as a result of a decrease in rainfall (H. Brown, 2009).

During late 2009 and early 2010 Turpie et al. conducted a study on the link between tourism and climate change. As background Turpie et al. cite the combination of wildlife use, for meat for example, and tourism, as contributing 5.5% of GDP, compared to 6.8% for mining, 5% for fishing and 4.5% for agriculture (Turpie et al., 2010). They also make the point that only 5% of Namibian wildlife is found in National Parks, with a further 10% in communal areas and the balance, 85%, occurring on freehold land (Turpie et al., 2010). Following the same climate change scenarios as used by Helen Brown and Midgley et al (the Hadley Centre HADCM3 model and the IPCC A2 storyline) they predicted a national decline in wildlife numbers of 13%

by 2050 and 24% by 2080 - considerably less than the 24% by 2050 and 48% by 2080 that they predicted for domestic stock (Turpie et al., 2010): refer to table 2.4 below.

Farming system	Present		2050		2080	
	Area (ha)	Cattle	Area (ha)	Cattle	Area (ha)	Cattle
Small scale mixed[10]	5 500 000	600 000	5 500 000	504 000	5 500 000	408 000
Cattle ranching[11]	31 500 000	1 400 000	22 500 000	984 000	13 500 000	524 000
Small stock[12]	27 000 000	180 000	29 000 000	172 000	34 000 000	177 000
Intensive[13]	40 000	5 000	80 000	10 000	120 000	15 000
Total	**64 040 000**	**2 185 000**	**57 080 00**	**1 670 000**	**53 120 000**	**1 124 000**

Table 2-4: 2050 and 2080 rangeland and stock predictions for Namibia (Turpie et al., 2010)

In their research Turpie et al distributed 347 questionnaires in Namibian national parks and at the international airport in Windhoek and asked respondents to rate their response to six different climate change scenarios for Namibia. The maximum reduction in tourism for the worst case scenario was 15% (Turpie et al., 2010). This is less than the anticipated reduction in wildlife numbers averaged over 50 years or more, and assuming growth in tourism arrivals - previously around 15 % per annum from 1990 with slowdowns in 2000 and 2008 (Ministry of Environment and Tourism, 2010) - it is not a statistically significant reduction in numbers.

Importantly, this study only looked at tourists' response to a decline in wildlife numbers and the devaluation of the landscape; it did not, for example, evaluate the potential decline in numbers due to personal economic factors, an increase in flight ticket prices, or the introduction of a carbon tax or other surcharges.

When considering land use changes in the area in which the DDNR is situated, the Pro-Namib, it is very clear that there is a wholesale move away from livestock toward wildlife. Since the first property in the area was purchased for tourism in 1984 a total land area of between 230 000 and 400 000 hectares has changed from livestock farming to a form of nature-based use, being either tourism or wildlife farming (Odendaal, 2011). The area to the north of the NamibRand Nature Reserve seems to have experienced a similar shift in land use patterns, perhaps even more pronounced because of its proximity to the Sesriem/Sossusvlei complex and relative closeness to the tourism arrival and departure centres of Windhoek, Walvis Bay and Swakopmund.

Partly as a response to climate change and the need for adaptation, the Ministry of Environment and Tourism (MET), with funding from the GEF via the implementing agency, the UNDP, is currently in the process of initiating the Namibia Protected Landscape Conservation Areas scheme (NAM-PLACE) which covers five key conservation areas including the Greater Sossusvlei-Namib Landscape (Global Environmental Fund, 2008). Jonas Heita, the UNDP co-ordinator, is at present collating stakeholder contact information with the inception workshop scheduled for February 2011, at which time a Landscape Management Committee will be inaugurated (personal communication, e-mail: Heita, 27 September 2011). NAM-PLACE is the first management platform for the area that will include the MET. It has four primary goals: the promotion of sustainable development through biodiversity conservation; the promotion of tourism; identification of key interventions that would strengthen the conservation network in

Namibia and, the co-management of the Namib-Naukluft Park and the adjacent conservation areas (Global Environmental Fund, 2008).

It can be argued that under various scenarios the likely outcome of climate change for the area in which the DDNR is located is that livestock farming will become more marginal; wildlife numbers will be reduced, although not to the same extent as livestock; and consumptive tourism (e.g. trophy hunting) and non-consumptive tourism (e.g. photographic safaris) will become the primary enterprises of the area. As land uses change and adapt, more farms will turn to open rangeland and create compatible land uses with the National Park system to the west and a need will arise for “deeper co-management approaches, open landscapes and collaboration across land holdings – for both ecological and socio-economic purposes” (Turpie et al. 2010:107).

2.4 The psychology of tourism and climate change: perceived linkages

In 2000 Stoll-Kleemann et al. studied the psychological reasoning behind the justification of high energy consumption lifestyles in Switzerland - the psychology of denial. They found that while citizens were relatively well-informed about the consequences of an energy intense future they justified not changing their lifestyles through shifting the blame to others, to government, or to the apparent inconsequence of their own potential contributions (Stoll-Kleemann, Oriordan & Jaeger, 2001). Stoll-Kleemann et al. established that the focus groups they worked with were generally mortified by images of high-energy futures and yet at the same time virtually none of the participants were willing to take the kind of action that would lead to a low-energy future (Stoll-Kleemann, Oriordan & Jaeger, 2001). They also found that one of the areas of disjuncture was conflict between a particular behaviour that is chosen - for example going on holiday - and the need to do something about climate change. In studying this disjuncture they confirmed nine forms of denial, as per the table 2.5 below.

Metaphor of displaced commitment	I protect the environment in other ways
To condemn the accuser	You have no right to challenge me
Denial of responsibility	I am not the main cause of this problem
Rejection of blame	I have done nothing so wrong as to be destructive
Ignorance	I simply don’t know the consequences of my actions
Powerlessness	I am only an infinitesimal being in the order of things
Fabricated constraints	There are too many impediments
After the floods	What is the future doing for me?
Comfort	It is too difficult for me to change my behaviour

Table 2-5: Forms of denial
(Schahn in Stoll-Kleemann 1999; Oriordan & Jaeger 2001)

Stoll-Kleemann et al. ascribe the denial responses to a number of factors which are not mutually exclusive but rather are mutually supportive, including:

- A reluctance to forgo habits and lifestyles that are closely linked with a sense of self;
- the conscious or unconscious construction of linkages that make any perceived personal sacrifice to be greater than the perceived benefit to others (the tragedy of the commons);
- a denial that climate change is so serious that something needs to be done about it;
- a belief that there is / would be a technological quick-fix for the problem;
- an expressed lack of faith that government itself would actually be able to do anything about climate change (Stoll-Kleemann, Oriordan & Jaeger, 2001).

Susanne Becken researched the connectivity or lack thereof between tourism and climate change in New Zealand and Australia in 2003 in study groups of tourists and tourism experts. She found that even among tourism experts only 9% of respondents confirmed a direct link between tourism and the GHG emissions that lead to global climate change, with 30% of tourism experts believing that tourists would participate in an offset scheme such as tree planting simply because “it makes tourists feel good” (Becken & Lincoln 2004:340).

Overall around half of tourists questioned any link between climate change and tourism, with the general emphasis being on the effect that climate change would have on a tourist destination as opposed to the effect of tourism on the global environment. Tourists who perceived climate change to be an issue and were willing to do something about it constituted 36% of those sampled, but this did not mean that they directly linked their travels with climate change since 21% of respondents did not recognise any link whatsoever between CO_2 emissions and travel. Becken attributes this partly to tourists assessing risk in terms of benefit rather than potential impact (Becken & Lincoln, 2004). Tourists like to go on holiday and by recognising the link between tourism and climate change they would have to reassess the net benefit of their action. With 48 % of tourists being willing to plant a tree (much more than the 30 % predicted by the tourism experts) as a way of offsetting their environmental impact[10] Becken noted that the “preferred way of avoiding the dissonance resulting from actual behaviour and pro-environmental attitudes is to contribute financially while keeping the privilege of continuing current practices” (Becken & Lincoln 2004:340) which speaks to the ethical conundrum of carbon offsetting.

Tourists can thus be seen to be reluctant to change their lifestyle, preferring to completely or partially suppress the linkage between their actions and climate change than to completely forgo travel. In this respect tourists have opened up a gap that carbon offsetting can neatly step into: carbon offsetting fills a psychological need that will allow tourists to reduce the dissonance between undertaking an energy intense activity such as long-haul flights and its effect on the environment through climate change. But purchasing carbon offsets is an abstract

[10] The link respondents made between tree- planting and offsetting was not clear. Many were happy to plant a tree merely because it was perceived as being generally environmentally beneficial and not in an attempt to offset emissions (Becken & Lincoln, 2004). Becken recognised tree-planting as being contentious in the context of offsetting but nevertheless chose to use it since it was a relatively simple remedy that people could relate to (Becken & Lincoln, 2004).

concept - there is no direct material or personal benefit to purchasing an offset, rather an implied benefit to the greater good of having a lesser effect on climate change.

2.5 Carbon offset markets

Nowadays most airplane and vehicle types have an independently verified per kilometre CO_2 emissions figure and reasonable generalisations can be made about CO_{2e} emissions (Jardine, 2009) where the full distance travelled and the mode of transport used provides a generalisation of the fuel burnt during the trip. In the case of the DDNR local carbon usage can be calculated by recording diesel and unleaded fuel used by the generator and vehicles and liquid petroleum gas (LPG) used in cooking and heating. The remedies to ameliorate carbon usage are similar to those used on a national level in Namibia but on a much reduced scale.

The Kyoto Protocol mechanism whereby certified carbon offsetting projects (generally third world) that use waste products or clean energy sources in the place of fossil fuel energy can be used to offset the carbon production of carbon debtors (generally first world), but certification is an onerous process and the shifting of the carbon debt away from the source has ethical implications. This case study is no different in as much as it does not change the fundamental way that tourism business is conducted - people travelling long distances in order to experience cultures and conservation projects that they otherwise would not have seen firsthand - pursuits for which they receive personal satisfaction but this satisfaction has a cost to society as a whole: “The phenomenon of people acting for their personal benefit but against the good of society is commonly referred to as the tragedy-of-the-commons” (Becken & Lincoln 2004:341).

In terms of offsetting, figures vary depending on the source but a broad generalisation would be that the voluntary carbon offset or voluntary emission reduction (VER) market grew by around 200% between 2005 and 2006 with more than 150 retailers of carbon offsets worldwide, and between US$ 26 million (Ecosystem Marketplace, 2009) and US$ 91 million (Lovell, Bulkeley & Liverman, 2009) worth of VERs traded in 2006.

A 2009 study by Ecosystem Marketplace reported that 123 million tonnes of carbon valued at US$ 705 million was traded in 2008 (Ecosystem Marketplace, 2009) and the 2010 Ecosystem Marketplace report increased the 2008 trading figure to 127 million tonnes of carbon (Ecosystem Marketplace, 2010) and the World Bank report of 2010 by Kossoy and Ambrosi valued 2008 VER trades at 57 million tonnes worth US$ 419 million (Kossoy & Ambrosi, 2010).

Clearly some confusion exits as to what constitutes a VER and the total value of trades conducted, and this to some extent may mirror the lack of regulation in the VER market. By way of comparison, the regulated or certified emission reduction (CER) market completed US$ 144 billion worth of trades during 2009 (Kossoy & Ambrosi, 2010), more than 300 times the values of trades in the VER market.

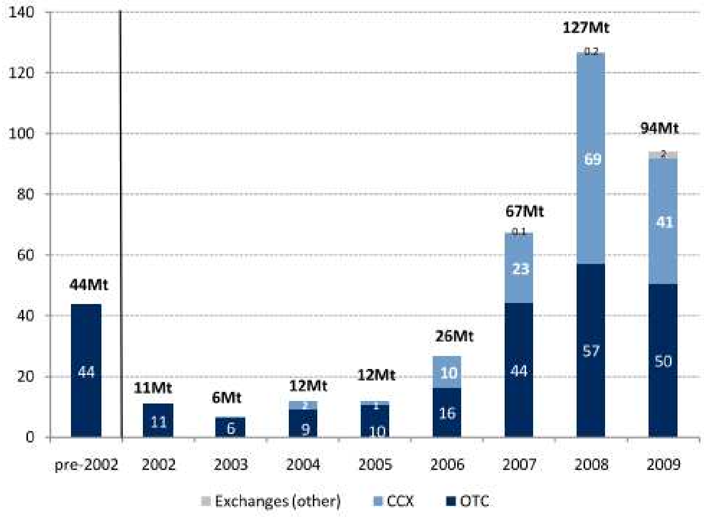

Figure 2-9: Growth in voluntary carbon markets
(Ecosystem Marketplace, 2010)

In a perceptive critique of offsetting Lovell et al. describe the concept as being problematic for consumers because a carbon offset is abstract. The consumer does not see or receive an immediate benefit from the carbon being offset yet still needs to receive a perceived personal benefit from purchasing it, thus: “consumer subjectivities are created through multiple narratives of carbon offset consumption” (Lovell et al. 2009:2). This is borne out by the fact that the overwhelming majority of trades are undertaken by corporate and state entities that are required by legislation to offset their CO_2 emissions.

The Chicago Carbon Exchange (CCX) along with several carbon retailers has addressed the lack of regulations and standards in the VER trading environment through the initiation of the Gold Standard for VERs. By 2010 around half of all VER trades on the CCX were independently verified (Ecosystem Marketplace, 2010).

By their very nature CERs should not be a permanent feature of the trading landscape and this is recognised through their limited lifespan, the idea being that once the emissions have been offset new CER certificates need to be traded for further emissions until such a time as the buyer re-engineers their carbon generation at which point in time the purchase of CERs will no longer be necessary.

2.6 Willingness to pay

With all of the uncertainty surrounding VERs it is challenging to determine whether WTP can offset carbon use, especially seeing as carbon trading has not yet being fully commoditised. As previously discussed, carbon trading schemes, whether voluntary or certified, trade in something that is not easily quantified. If carbon had an everyday direct value that could be attached to its use and activities that generated carbon were easily quantifiable, then the marginal benefit or cost of utilising carbon could be more easily determined - something like a currency: we are all aware of the value of our money and determining the marginal benefit of a product that has a clearly defined value, is easily done. Determining the marginal benefit derived from using a molecule of carbon is somewhat vague. As such there is little or no individually driven demand to consume offsets of carbon molecules, as there is in the conventional consumer-driven relationship to buy petrol. The CER market thus remains policy driven where corporations are required to offset their carbon use. By contrast the VER market is consumer driven, and consequently much smaller. Nonetheless, the exponential growth of the VER market and the introduction of the gold standard in VERs clearly illustrates that there is a growing demand for VER trades to enter the broader consumption landscape. The narrative is at work.

Accepting thus that some individuals are willing to pay something toward offsetting their carbon usage there is also a threshold point at which they would not be willing to pay any more. In this instance WTP surveys can sometimes misrepresent real responses, with respondents coming in at a lower price point than reality when they think they are being bargained with or higher than normal price thresholds when they feel a cause, as opposed to a product, to be more worthwhile. David Lyon states: “Willingness to pay is a lousy direct question to ask respondents, who tend to lowball their answers, in effect bargaining rather than answering accurately” (Lyon 2011:1). But the opposite may also be true: a WTP questionnaire could represent higher hypothetical values than real ones if the true cost of a good is yet to be determined. Previous WTP research also seems to indicate that using a price point to some extent predetermines the answer. If no price points are given and a simple ‘how much would you pay’ question is asked, significant numbers respond that they will not be willing to pay at all, however, when a specific price point was given and prices were kept low, only 25% of respondents were unwilling to pay (Farhar, 1999).

In 2008 a WTP exercise for carbon offsetting was conducted among young adults in the UK who had a higher education degree and who flew regularly. In this group nine out of ten had heard of carbon offsetting, and just fewer than one in four had actually paid to offset their carbon use on flights (Mackerron, Egerton, Gaskell, Parpia, & Mourato, 2008). These are significant figures, but have to be seen in the context of the fact that a very specific subset of the general population was surveyed. As many studies have found WTP is also a function of individual awareness and in instances where WTP for RETs has been tested, individual knowledge of the benefit of renewables has often been vague, but there is still a willingness to pay slightly more for energy from renewable sources than for conventionally sourced power (Farhar, 1999).

A study conducted by Kostakis and Sardianou in Crete during 2010 researched the WTP a premium for hotels that used RET sources of energy. 320 Tourists were surveyed and the results indicated that 45% of these would pay extra to stay in a hotel that utilised energy from RE sources (Kostakis & Sardianou, 2010). Significantly, 71.3% of all those surveyed had implemented some sort of energy-saving measure in their own homes (Kostakis & Sardianou, 2010). When compared to the 2000 study of Susanne Becken concerning the connection between tourism and climate change there is little difference between Becken’s results and the results of Kostakis and Sardianou, although perhaps the study by Kostakis and Sardianou bears out that consumers have become at least somewhat more energy conscious in the 10 years that lapsed between the studies.

In the context of the DDNR we can thus identify several factors that could affect the validity of the results of a WTP survey.

- Climate change: Causality between climate change and an increase in global temperatures is well researched and documented but a WTP survey should give respondents the opportunity to not confirm a link between climate change and their actions necessarily leading to global warming. If they feel that climate change is a natural phenomenon and the hype surrounding it is nothing but that, hype, then they will probably not be willing to contribute to any form of carbon offsetting.

- Individual value systems: According to the Stoll-Kleemann methodology denial may take several forms - there will be a technological quick fix, reluctance to change lifestyles, and the tragedy of the commons - if no-one else is doing anything about it why should I? In this context, while the link between climate change and lifestyle may be acknowledged it will not necessarily provide impetus to change. A WTP survey would therefore need to allow respondents to affirm the link, but also provide space for them to deny a need to do anything about it.

- Carbon trading and certification schemes: While the IPCC states that it believes carbon will become a tradable commodity with a standard fixed cost (Intergovernmental Panel on Climate Change, 2000a) paying for carbon remains a somewhat abstract and unfamiliar concept. Moreover, as the figures discussed reflect, there is clearly still some uncertainty within the industry about the certification of VERs. Respondents in a WTP survey who indicated some level of WTP would need to be able to choose whether they supported an audited or unaudited VER scheme.

- Factors affecting level of support: This is probably the most difficult aspect of WTP to gauge. Climate change involves intergenerational time frames that are very difficult for individuals to quantify (Beckerman & Hepburn, 2007). Making a carbon payment today has no immediate benefit to the payee. Rather, it sets in motion a cycle of incremental change that has a very long term reward for subsequent generations. If support has been determined, then the level of support needs to be gauged and this would have to take the form of a range of choices that have direct monetary value. Factors affecting support are probably best provided anecdotally in the discussion section of a WTP survey.

The interaction of this myriad of decision-making influences makes it clear that WTP is not an ideal methodology, but in the absence of any previous WTP surveys on VERs in tourism in Namibia it is a starting point that can be used as the basis for further research.

2.7 Quantifying GHGs

The ISO standard 14064-1 of 2006 outlines the methodology used to calculate the global warming potential of the various GHGs.

- According to the ISO standard the units of GHG measured have to be defined in terms of the organisational boundary. The DDNR is an easily defined entity since it has a single geographic boundary and is a stand-alone business unit within the greater

Drifters organisation. This definition satisfies the ISO standard 14064-1 reporting requirement.

- All GHG emissions should be identified, quantified, and calculated according to the prescribed ISO methodology. Total GHG emissions can be either calculated or measured directly or a combination of the two. In the case of the DDNR, a combination of calculation and measurement were used.

- The prescribed unit of measurement for measuring GHGs is in tonnes, and for a final figure all units should be adjusted to reflect carbon dioxide equivalent - CO_{2e} of each GHG. As mentioned in the introduction, the relevant GHGs include methane (CH_4), nitrous oxide (N_2O) and CO_2. Other GHGs listed by the ISO, the fluorocarbons and hexafluoride, are the by-product of industrial activities and are not applicable here.

- The measurement shall be calculated or extrapolated out to reflect usage over a period of one year, 365 days, which will initially be known as the 'base year'. In establishing the base year the organisation has to explain why the particular year was chosen and develop a GHG inventory for this year.

- In order to ameliorate GHG emissions the ISO standard uses the following as examples of management interventions: energy demand and use management; fuel substitution and / or fuel switching; procedural and / or technological improvement; management of transport and travel; afforestation; energy efficiency; and GHG capture and storage. Each of these has relevance to the DDNR.

- Other requirements of ISO 14064-1 include that quality control checks need to be conducted and documents and records need to be kept to ensure accountability.

2.8 In summary

The IPCC has clearly confirmed, to a high degree of certainty, a link between climate change and anthropogenic GHG emissions, and tourism is guilty of contributing a substantial portion of emissions to the global milieu of GHGs. The argument that tourism contributes to attaining the millennium development goals and the sustainable development of local economies is counter-intuitive and a function of the dissonance between undertaking an energy intense activity and fulfilling a psychological need not to change lifestyles.

It is thus critical that a transport based industry such as tourism clean up its act and set tangible and legally binding targets for reducing its global environmental footprint in order for it to become sustainable. The ISO 14064-1 does take into account imported GHG emissions and then subsequently ring-fences organisation emissions (International Standards Organisation, 2006). In this sense the airlines, and not the DDNR, need to offset the emissions produced by their activities and in order to quantify its own footprint the DDNR only need take into account the GHGs that it produces from its own activities.

In the context of Namibia, the DDNR has to pursue the concurrent goals of sustainability and carbon neutrality in its own right. Reducing the carbon intensity of the Namibian economy is not a policy driven legal obligation and at any rate Namibia is a net carbon sink (Ministry of Environment and Tourism, 2011). Large scale fossil fuel based plug-in energy solutions receive more ministerial support in Namibia than smaller scale and technologically immature RETs with the adoption of RETs been driven on a piecemeal basis. As yet NamPower registration or ECB grid connectivity for IPPs is not an option and funding for RETs is restricted to private individuals and occasional headline NGO projects. Commercial trading of certified emissions certificates is not occurring in Namibia and the trading of forestry credits under the CDM of Kyoto is unlikely. Carbon sequestration, even in a dryland scenario, holds promise but it is not yet possible under the current CDM trading regime.

But, climate change is Namibia is a proven reality and as a consequence thereof the traditional rural income generator of commercial and subsistence livestock farming it going to become more marginal. Wildlife farming and its associated tourism, especially if it is collaborative and involves open rangelands, has the potential to do comparatively better but will also suffer under a changing climate regime.

The psychology of denial and a reluctance to forgo lifestyles opens a window of opportunity for the trading of voluntary emission reductions that can contribute to real change at a local level and can contribute to making organisations such as the DDNR more sustainable. While in no way pretending to ameliorate the carbon debt of a tourist’s full travel experience, the DDNR, by accepting its place in the travel economy, can make meaningful local change that can in part be funded, with provisos, by its clients, the tourists.

3 Methodology

3.1 Clarification

The research process is separated into two distinct components. The first part of the research involved conducting a survey on willingness-to-pay a voluntary amount towards off-setting the GHG emissions of the organisation. The potential contributors toward the off-setting are the clients of the business unit, the Drifters Desert Nature Reserve (DDNR), which, as mentioned in the introduction, has two sub-units, the Drifters Desert Lodge (DDL) and the Drifters Desert Camp (DDC). The DDNR is one of 14 lodges and properties that form a part of a greater shareholding structure within Drifters Adventours.

The second, concurrent, exercise defined, measured and collated the GHG emissions of the organisation according to the ISO standard 14064-1, the internationally recognised standard for detailing the methodological processes undertaken to quantify organisational GHG emissions. ISO standard 14064-1 draws on empirical data from the IPCC (International Standards Organisation, 2006) and broadly follows the methodology used by the GHG Protocol of the World Resources Institute on which it is based (World Resources Institute, 2011). In order to provide a baseline of GHG emissions all figures are extrapolated out to represent the emissions that would result from one year of operation.

In order to measure the contribution that an off-set or VER payment can make towards real and definable change, alternative, more efficient and less carbon intense technologies are costed, and savings derived from demand side management through improved operational efficiencies and management interventions to change mindsets - a hearts, minds and chequebook approach - are broadly discussed.

If a level of willingness-to-pay for offsetting at a local level can be determined then this can be used as a balance sheet item to subsidise the cost of technological change and when combined with improved operational efficiencies the DDNR could move toward becoming a less carbon intense organisation.

3.1.1 Role of the researcher

The research was conducted by the Reserve Manager of the DDNR. The reserve has a permanent staff complement of two, the manager and a single labourer. When there are guests at the lodge or large jobs to complete on the property a temporary lady and sometimes a second labourer are recruited to help clean the rooms, do washing, wash windows and cook for guests. As for the campsite, it pretty much runs on its own. The game drive vehicle is dropped off at the camp and the guide that accompanies the Drifters groups conducts the game drive and the guided walk. Being the manager, the researcher had access to all the necessary documentation and was responsible for all the purchasing and accounting.

Permission for the quantitative carbon-based research as well as the dissemination of questionnaires was obtained from the owners of Drifters Adventours, who are also the owners of the DDNR.

3.1.2 The survey

During March, April and May of 2011 extensive surveying took place and a total of 121 questionnaires were completed by guests of the DDNR. Of the respondents 90 stayed in the campsite and 31 stayed in the lodge. A brief introduction was given and the questions asked were exactly the same in both locations. Not all of the respondents answered all of the questions and data was analysed accordingly.

When staying at the DDNR clients are taken on a game drive after which they generally relax around the fire in the case of the campsite or have a drink in the dining area when they are staying at the lodge. This was the ideal time to present the questionnaires. A rapport had already been established with the clients and it was easy to engage with them and explain what the questionnaire was about. Further, most of the clients did not have English as a first language and often considerable explanation was necessary about the concept of carbon use, long-haul flights, local carbon offsetting, and the structure of a potential carbon offsetting scheme at a place like the DDNR.

In presenting the questionnaires clients were reassured that they were not being asked to make any contribution toward offsetting carbon use: all that was being established was a price point for a potential carbon payment. It was also explained that the cost of any change would not be borne exclusively by clients. Drifters would bear a considerable portion of the cost of change including salaries and wages of the staff and the tools and expertise needed to complete the job. In line with concerns about the researcher's easily assumed linkage between climate change and emissions, respondents were specifically asked to make it clear if they were willing to participate in a carbon offset scheme or not. If they were not, they were asked to say so and were not asked any further questions.

In establishing a price point it was decided that a range of pricing options would be given to the respondents, a stated preference request which asked respondents to choose between four options (interval variables). Whilst this approach may lead to respondents under or perhaps over stating their actual WTP, it does more accurately reflect the choices that a consumer faces in the market place (Mackerron et al., 2008).

During the survey several respondents asked if the price points presented were an accurate reflection of the real cost of change. When told that the cost of change had at that point not yet been determined, they appeared disappointed at having to make up their own minds about choosing a price. It became clear that if a respondent was presented with a direct cost of change that this would have weighed heavily on the price point. Partly as a result of this it was decided that a real cost of quantifiable change which would result in measurable reductions in carbon use had to be calculated as far as was possible and the result had to factored into the research and balanced with price points.

Completion of the questionnaires often resulted in considerable discussion amongst the clients and questions were asked which did not form a direct part of the survey. In line with previously mentioned reservations about VERs, a number of clients sought reassurance that a carbon payment would actually contribute to real change at a local level. It became clear to the researcher that a VER payment is a two way process that creates a relationship between the payee and the receiver and that the payee would need reassurance about the application of the payment. Thus, as mentioned, in implementing a VER scheme transparent and measurable goals would need to be defined and outcomes made available.

As predicted by the extant literature the need for follow-up was also often linked to the level of payment. If trust was implicit in the structure of the relationship payments were likely to be higher and greater transformations in energy configuration could be gained. Notes were taken on interaction with the respondents and they enable a broader and more holistic descriptive overview of the results.

3.1.3 Empirical analysis of questionnaires

Empirical results were analysed using multiple and logistic regression. Logistic regression can clearly describe the relationship between the probability of an event occurring - a binary response variable with a yes or no answer (in this case the dependant variable is a willingness to pay) and independent variables such as age or origin of the client (Farhar 1999; Wedgwood & Sansom 2003; Statistica 2012). The independent variables were where the clients were staying (the lodge or the camp), their age, and their country of origin. In determining the WTP four price points were given and these were analysed using multiple regression (Wedgwood & Sansom, 2003) in order to accurately reflect at which point WTP became valid.

During the period of research, 1 October 2010 until the 30 September 2011, the DDNR received 1055 clients. Of these, 121 completed questionnaires which equates to 11.47% of clients. In statistical analysis of correlation research a significance value of over a 5% sample is considered a statistically significant number of respondents (Wedgwood & Sansom 2003; Statistica 2012).

3.1.4 Structure of questionnaires

There were no prerequisites and all respondents were canvassed equally. The following generalisations can be made about the respondents:

- They earn enough to travel for leisure, which implies that they have a particular income generating ability;
- They have generally, although not always, taken a long haul flight to get to Southern Africa;
- They are not Namibian citizens or residents;
- They are older than 18 years old, this being the minimum age requirement to participate on an overland tour and combined with the fact that over the period of the survey no children stayed at the DDL.

The first two framing questions, the independent variables, were not numbered and descriptive, and asked the age and the nationality of the respondents. Thereafter the questions were numbered as follows:

Question one is a binary variable which asks if the respondents made use of a carbon offset scheme when they booked their holiday. This question provides insight into the market penetration of offset schemes in the VER market, especially when considering that airline emissions, the largest portion of the carbon used by clients on their holiday, are not controlled by Kyoto or other mechanisms. If respondents answered yes to this question it may be assumed that it would be likely that they would also be willing to contribute to a VER payment at the DDNR.

Question two asks respondents if they would pay to offset their carbon usage while at the DDNR. This is the WTP independent binary variable with a yes or no answer. If the answer was negative no further questions were asked and the survey was terminated. If the answer was positive then the respondents continued to question three, which are dependent variables.

Question three asks respondents if they would prefer to make an offset payment in advance of their stay at the DDNR or if they would prefer to pay on arrival where they can see progress being made. This question reflects the trust placed in VERs as an abstract offsetting mechanism. If the respondent was happy to pay in advance then it can be assumed that the convenience of a single payment for both the accommodation, services and carbon outweighed the need to see the ‘process of change’ in action.

Question four presented the respondents with four price points, the dependent interval variables, which were analysed through multiple regression analysis: N$20 or less, N$20 to N$50; N$50 to N$100; and an amount over N$100. Presenting respondents with a range of figures within which they could choose was assumed to make the choice of price point easier for the individual (Mackerron et al., 2008). The choice of figures was based on WTP stated preference research conducted by Mackerron et al. on offsetting carbon when travellers purchase airline tickets in the United Kingdom which took the values GBP £4, £8, £12, £16 or £20 as representative of current offset choices faced in the market (Mackerron et al., 2008). At the current exchange rate of around N$12 = GBP £1 (Standard Bank, 2012) the figures chosen for this research equate to a range between N$48, N$64, N$96, N$128 and N$160. Since airline tickets are valued at several times more than one night’s stay at the DDNR the figures used may be optimistic, but, if they are somewhat familiar to the clients, even if they did not use an offset program when the purchased their flight ticket, then price resistance may also be less. When calculating the results the lower figure of the range presented was used in order to err on the conservative side and thus the WTP result can be considered the minimum possible result within the price points offered.

Question five is a part repetition of question three in that it asks respondents if they would be satisfied receiving regular updates as to the progress of the off-setting exercise, or whether they would prefer the scheme to be professionally audited. The proviso was added that auditing would add to the cost of the scheme. This question again reflected the level of trust that a user will put in a VER program. Once a client has been to the DDNR a degree of trust or rapport may have been established and this could lessen the need for a follow-up. Alternatively should an intrinsic mistrust of VERs weigh heavily on a respondents mind then a follow-up would be required regardless of the nature of the relationship during their stay.

3.2 Measuring the CO_2 debt of the DDNR

At the DDNR the five primary energy consumers and their respective uses are:

• Toyota Land Cruiser 4X4	game drives
• Toyota Hilux 4X4	Logistics, including shopping, staff courier
• John Deere generator	Geyser water and a battery charger
• John Deere gator utility vehicle	general utility vehicle
• LPG gas	cooking and heating water for showers

As discussed in point 2.7, according to the ISO Standard 14064-1, GHGs that need to be included in the calculations include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride (International Standards Organisation, 2006), the combination of which are referred to as the carbon dioxide equivalent -CO_{2e}. The fluorocarbons and the hexafluoride are not the result of vehicular emissions and are thus not relevant to the research.

With regard to CO_2, CH_4 and N_2O the following reasoning was pursued: the production of the gases CH_4 and N_2O are dependent on the type of emission control system used and catalytic convertors that have a limited lifespan that is dependent on the fuel burnt, if additives are used and the whether the vehicle is using oil or not (Lipman & Delucchi, 2002). In the case of the Land Cruiser it has never had a catalytic convertor; it is safe to assume emissions are thus higher than would normally be the case (Maidment, 2012). But, without the benefit of specialised exhaust emission measuring equipment, it is impossible to be exactly certain how much CH_4 or N_2O the vehicle produces.

Also, in South Africa when carbon taxes are applied the calculations are based on emissions measured according to the South African Bureau of Standards SANS20101:2006, as adopted from the United Nations Economic Commission for Europe standard ECE R101, which only requires that CO_2 be measured (South African Bureau of Standards 2006; Toyota 2012). Similarly the United Kingdom and Australian emissions tax standards require only the measurement of CO_2 (DirectGov UK 2011b; Australian Government 2011). For the purposes of this research it was thus decided to measure CO_2 only and not include N_2O or CH_4 despite CO_{2e} and not CO_2 being the reporting requirement of the ISO 14064-1 standard.

It should be borne in mind however that CH_4 and N_2O can contributed up to 15% of the lifecycle emissions and in order to accurately quantify the full GHG emissions of an engine measuring equipment needs to be employed (Lipman & Delucchi, 2002).

3.2.1 Toyota Land Cruiser

The Toyota Land Cruiser is used on shorter distances but more often than the Hilux so the fuel debt remains significant. In the case of the Land Cruiser fuel receipts were not available but all distances were recorded. Thus with an average fuel consumption calculated and knowing the price of diesel for the measuring period, as per the Hilux, a reasonable generalisation could be made about the amount of fuel consumed and therefore total emissions. When comparing the emissions of CO_2 as given by the UK Government and the US EPA diesel conversion standard to actual fuel burnt, the UK Government figure for the Land Cruiser was found to produce over 30% more emissions than the US EPA figure[11] predicted. This illustrates that caution must be taken when making generalisations about fuel consumption and emissions figures. The UK Government figures were used.

In order to test the consumption figures per distance travelled against the average cost of the diesel over the year the two were compared. The average price of diesel was calculated at N$ 9.05[12] and when annualised this figure translated into an annual 5 837 litres of diesel consumed. When taking the consumption figure and apply it to distance travelled a total of 6 396 litres of fuel was calculated to have been consumed. Therefore either consumption figures are marginally overstated or the average price of diesel or the actual pump prices were different, or both factors have played a role. The two figures are however close enough to each other for measurements of diesel consumed in the various vehicles to be assumed to be more or less correct.

3.2.2 Toyota Hilux

In the case of the Toyota Hilux no logbook was kept, fuel receipts were not available, and the vehicle is used for personal as well as business use. Fortunately only the fuel that relates to business use is put through the balance sheet, and since it is the only vehicle that runs on unleaded fuel the amount spent on unleaded fuel divided by the average pump price will give a rough estimate of the fuel consumed.

Pump prices of ULP were obtained from the MME website but average prices should not be taken as conclusive, rather as a rough indicator, since there are some undoubted inaccuracies: pump prices change during the course of month, at a day predetermined by the MME, so the month of the announcement on the website will not give an accurate per day fuel price figure; and pump prices were taken to be located at Maltahöhe, yet the Hilux is refuelled in several other towns many of which will have differently priced fuel. On balance, the figures give an estimate which is sufficient for the research. Emissions figures were sourced from the UK government database and extrapolated out to provide an emissions estimate for a 12 month period.

3.2.3 John Deere generator

The generator's hours of use were recorded every day and collated every two weeks. Fuel consumption was estimated, and all general maintenance such as services and parts

[11] 6 858kg CO_2/yr as opposed to 5 048kg CO_2/yr.

[12] Appendix I.

replacement was recorded including the date and the cost of the maintenance performed. One aspect that was not measured was the time taken to perform the tasks. Strictly speaking, since the person who performs the maintenance, the Reserve Manager, earns a salary, this should also have been considered.

Despite numerous requests to John Deere there were no emissions figures forthcoming and as a result a very generic conversion factor of one litre of diesel equals 2.65kg of CO_2 was used, a figure sourced from the United States Environmental Protection Agency (US EPA) website (United States Environmental Protection Agency, 2005).

3.2.4 John Deere gator utility vehicle

The gator's use is recorded in hours by an hour meter. Diesel use was estimated by filling up the gators fuel tank, driving it for one hour, and then filling it again and measuring how much fuel was used. In the case of the gator very little time has been spent on maintenance and it was not operational for much of the base year that was measured.

As with the generator numerous requests and much email correspondence did not produce an accurate emissions figure and although the motor, a Yanmar diesel, is listed by the US EPA as having been emissions tested and emissions figures are available these do not reflect CO_2 emissions. For this reason the same emissions conversion factor used for the generator was used for the gator - one litre of diesel equals 2.65kg of CO_2 (United States Environmental Protection Agency, 2005).

3.2.5 LPG

According to the ISO standard on which the GHG reporting is based it is not necessary to include LPG and it is not listed as a GHG (International Standards Organisation, 2006). The ISO probably bases this on the fact that the IPCC does not consider LPG to be a GHG (Atlantic Consulting, 2009). But LPG is a fossil fuel and even though it has a low carbon-to-hydrogen ratio (calorific value) and this means that it generates more heat and less carbon than comparable fuels (Atlantic Consulting 2009, World LP Gas Association 2011) it nonetheless adds to the CO_2 burden of the DDNR.

With regard to its environmental rucksack all LPG used in Namibia is imported in pressurised bulk containers and distributed around the country (personal communication, Mendonca, A.,15 October 2011). The LPG that the DDNR uses has to be transported to the reserve by the Land Cruiser which adds considerably to the use of the vehicle - LPG canisters are very heavy and bulky, and at this stage of the business cycle the DDNR does not use enough LPG to justify receiving its own deliveries from an outside agency. Also, as the World LP Gas Association states, while LPG has a higher calorific value or energy per kilometre than conventional fuels and it is cleaner burning, it remains a GHG (World LP Gas Association, 2011). The emissions involved in transporting the LPG, while external to measurement requirements of the DDNR, nonetheless need to be taken into account and it was thus decided to include LPG emissions in the overall rating of the DDNR.

4 Methodology

4.1 Questionnaires

In the analysis of the questionnaire the results were separated between the Drifters Desert Camp and the Drifters Desert Lodge, the reasoning being as follows:

Drifters Desert Lodge	Drifters Desert Camp
Clients at the lodge are fully independent travellers, and as such they arrive in their own vehicles and stay for a length of time that they determine depending on their itinerary, the time that they have for their holiday, finances, and their own priorities.	Clients at the campsite are on a guided and pre-booked set itinerary tour. They stay for a set time (two nights) and then depart to their next destination.
Staying at the lodge includes all meals and a game drive. The lodge has an extensive lawn area, a swimming pool, en-suite rooms, a kitchen, a fridge, and a fireplace.	There are fewer facilities at the campsite. There are only two showers and two toilets, divided into men's and ladies ablutions. There is a rock pool for swimming, but the water therein is not filtered.
The lodge has no 220V power. The pool filter is 12V DC and lighting is all 12V. The fridge and the stove in the kitchen use considerable quantities of LPG and the showers are heated by LPG. The one major difference between the two facilities is the lodge lawn. In summer it needs to be watered every two days, approximately 1000 litres a time. This water is drawn from underground and then pumped up to the lodge.	The campsite has 12V lighting powered by batteries which are charged by solar panels in both the kitchen and the toilets. The showers are heated by LPG but usage is minimal. The pipes feeding water to the campsite showers are black and absorb the heat and clients showering during the day do not have to use the hot water tap for hot water.
It can therefore be assumed that the lodge will naturally have a higher carbon debt than the campsite.	The campsite is busier than the lodge with many more clients but it is still safe to assume that it will have a lower carbon load than the lodge.
Importantly, the clients at the lodge have a different price point and therefore it can be assumed a generally higher income level. Prices at the lodge start from €100 per person per night (Drifters Adventours, 2011).	Clients at the camp pay for their stay as a part of the longer tour. The cost of the CV tour is €1 895 for 24 days, the equivalent of €79 per day (Drifters Adventours, 2011).

4.1.1 Results of questionnaires

The detailed results of the questionnaires are given in Appendix A (combined results), Appendix B (Drifters Desert Camp) and Appendix C (Drifters Desert Lodge). For the purposes of this research they are summarised as follows. A total of 121 questionnaires were completed. Grouped statistical results are presented in Appendix A. A total of 103 respondents answered the question relating to age with an average age across groups of 34 years.

DDL clients were considerably older than the clients that stayed at the DDC with an average age of 55 years as opposed to 27 years. However, as reflected in the appendices, confidence factors are low since the number of DDL respondents was relatively low and coincidentally at that time fairly old. Subsequent clients have been younger, but remain nonetheless older on average than the clients of the DDC.

All 121 respondents answered the question related to nationality and the majority, 39%, were Norwegian, and the second largest group of respondents were German at 17%. The time of the year that the survey was undertaken skewed this figure since March and April are traditional travelling months for Norwegians and Drifters has a very supportive travel agent in Norway who sends many clients on the CV tour. When looking at disaggregated results it appears that the DDC clients had a disproportionate number of Norwegian clients, 53%. This ratio changes considerably later in the year with many more German clients than Norwegian and this is a factor that may affect the validity of the results.

Overall the majority of respondents were European, some North American, and there were a few Australians and some South Africans at the lodge. There were no respondents that were from any other continent. In terms of itinerary chosen, 80 of the respondents were on the CV tour and nine were on the Namibia tour. The rest, 31, were staying at the lodge. One person did not complete the question on nationality.

Question one: “Did you make use of a carbon offset scheme when you booked your holiday?” Only two respondents out of a total of 121 responses made use of a carbon offset scheme when they booked their holiday. This equates to less than 2% of respondents. One of these was a 32 year old from the UK and the other was a 19 year old from Norway.

Question two: “Would you pay towards offsetting the carbon used by hosting you at the (DDC/DDL)?” All 121 respondents answered this question with 88 positive responses and 33 negative responses. Thus, 73% of respondents said that they would pay something toward offsetting carbon use at the DDNR.

Question three: “If yes, there are two ways in which we can introduce a payment system a) building a ‘carbon cost’ into the rates charged, or b) by charging a separate carbon fee that would be paid for while in residence”. The vast majority of respondents, 84%, who stated that they would pay toward offsetting the carbon at the DDNR, preferred the fee to be built into the cost of the accommodation or tour that they were choosing. Only 14 respondents chose to have a carbon payment be made separately and on arrival at the DDNR. This presents a somewhat problematic operational conundrum for the tour operator.

Firstly, Drifters Adventours charges an all-inclusive rate which is commissionable to the travel agent who on-sells the tour. It would be challenging to separate out a commissionable and a non-commissionable portion to the client’s payment since this would result in double payments for each booking and it would attract double bank fees and other charges and many agents would simply not be willing to deal with this added administration. Secondly, a VER payment should be an ‘off-the-balance-sheet’ payment, not an income, and should thus not attract penalties. If, as is possible in the case of the DDNR, it was a cash payment made directly to the DDNR, it could be structured accordingly, but should Drifters Adventours as a group decide to implement a VER scheme the structuring of such a payment would need to be investigated thoroughly. A third problem arises: how to make it clear to the consumer that a separate carbon payment is possible. When communicating directly with a client it would be relatively simple for Drifters to make this connection, but a very small percentage of clients make their reservations directly and with the vast majority booking via a wholesaler, direct client communication is convoluted.

Drifters have prior experience of trying to exact separate payment from wholesalers and travel agents. In the case of some of the East African countries many of the costs are US$ based and in order to hedge against currency fluctuations between the Rand and the US$ a separate payment was instituted that was required to be paid in US$. The system was opposed by agents and in the end Drifters decided in favour of a local cash payment, communicated up front, directly from the client. In order to effectively implement a VER payment it is suggested that a similar payment method may have to be used, cash on arrival.

Question four: “What would you be willing to contribute towards a carbon neutral goal here at DDNR?” Four options were given: N$ 20 or less, N$ 20 to N$ 50; N$ 50 to N$ 100; and an amount over N$ 100.

When comparing the 90 clients surveyed at the DDC as opposed to the 31 surveyed at the DDL the level of willingness to pay something was almost the same: 72% versus 74%, but the level of payment that would be considered differed considerably. Of the DDC respondents 16% would consider a payment of under N$20, 58% would consider a payment of N$20 to N$50, 23% would pay between N$50 and N$100 and 3% would consider a payment in excess of N$100. None of the DDL respondents that were willing to pay considered the low figure, 26% would pay more than N$20, 48% would pay more than N$50 and 26% would pay more than N$100. Thus while the ratio of yes versus no with respect to WTP of DDL client’s remains consistent with that of the DDC the level of payment that would be considered was higher

When combining all yes responses, 11% opted for a payment of N$ 20 or less, 49% opted for a payment of between N$ 20 and N$ 50, 30% opted for a payment level of between N$ 50 and N$ 100, and 9% of respondents indicated a willingness to pay more than N$ 100. Assuming that the respondents chose the lower end of the range of figures presented and extrapolating this out to annualise the figure, an estimate of an annual amount can be derived. The total number of lodge clients and tour participants in the previous year (1 October 2010 to 30 September 2011) was 1055 (Drifters Adventours, 2011). If 11% opted for a payment of N$ 10, 49% opted for a payment of N$ 20, 30% opted for a payment of N$ 50 and 9% opted for a payment of N$ 100 then the total VER pool for the past year would be N$ 36 180. It must be borne in mind that this is somewhat speculative: willingness to pay surveys are a problematic concept, no demand curve was derived, and the sample was not broadly reflective of the demographics of the clients attracted to the DDNR - travel is seasonal with different international markets travelling at different times of the year.

The last question, question five, asked respondents if they would like the carbon-offset scheme to be professionally audited, if they would be satisfied with direct email contact from DDNR about the progress of the program, or if they would prefer not to be kept updated at all. In this case 13% of respondents opted for a professionally audited scheme, 40% said that they would be satisfied with email updates from Drifters, and 48% considered the payment to be the end of the relationship between themselves and DDNR, opting for no updates. This is interesting since it reflects an assumed level of trust between Drifters and the client. Clients are obviously fairly confident that if a payment is made then it would be used appropriately. In reality it would probably be better to present clients with the option to receive updates or not and for those that choose to receive updates to be able to receive them.

4.1.2 Anecdotal observations

At the end of the questionnaire participants were encouraged to complete an open-ended section with general observations about the initiation of an offset scheme at the DDNR. Several interesting comments were made that reflect the general uncertainty around carbon offsetting.

- “Too much corruption.”

There were two individuals who made this comment. One was an Australian and the other was an American and both had reservations about the way their governments were tackling climate change.

- “Educate Drifters guides.”

During the course of the survey, and in general discussion with the guides who accompany the tours, it became clear that whilst the Drifters guides were certainly environmentally aware, in the narrow sense of the phrase, climate change and carbon offsetting were vague and unfamiliar concepts to them. For any carbon-offset scheme to work Drifters guides would need to be made aware of the reasoning behind implementation and the consequences thereof. They are a critical interface with the clients.

- “Drifters are clearly doing well. We support the initiative but Drifters needs to contribute the bulk of the cost.”

This is an expected reaction from a back-packer on a budget tour with little cash to spare. In this case transparency is very important. Participants must be aware of the progress of the project, how costs are being allocated, and what benefits are being derived.

- “If I pay N$20 for my time at the DDC, then I have to pay N$200 for the whole Drifters trip, and this is too much.”

It would be necessary to make decisions about at what level an offset scheme would be implemented. As the above comment makes clear, it would not be possible for each lodge in the Drifters chain to develop and implement their own scheme. A better approach would be to calculate the group-wide carbon footprint and implement a scheme at group level. When one considers that the CV tour is 24 days long and the time spent at the DDNR is two days, in this case WTP equates to N$ 10 per day, or around N$ 240 for the trip.

- “It would make more sense not to travel so far.”

This comment reflects the broader concerns of the travel and tourism industry. It is not possible to gauge at this stage what percentage of potential travellers have postponed, curtailed or cancelled travel plans due to concerns about the impact on the environment but, as discussed in chapter 2, the comment does reflect a concern of the tourism industry as a whole.

- South African versus international perspectives

An anecdotal observation made while conducting the survey was that most of the European clients were readily engaged and happy to contribute but this was definitely not the case with South African clients. The three South Africans who participated in the survey were very sceptical and not willing to contribute. Subsequent South African clients who have stayed at the lodge have confirmed this as being a trend. While not a formal outcome of the research, it seems clear that Europeans are more open to the possibility of carbon payments than South Africans.

Other comments made included:

- “My own government taxes me to death; I’m not interested in paying any more.”
- “No commission to travel agents.”
- “Be specific about amount.”
- “Very willing to contribute.”
- “Pay after the trip is done to see Drifters in action.”
- “Really want to see in practice.”

4.2 Energy

4.2.1 Solar cooking

A very effective solar cooker at the manager’s residence is used for cooking meals for staff and lodge guests. The learning curve associated with using an unfamiliar technology such as the solar cooker has meant that the cooker, while initially underutilised, has been used more frequently of late and LPG use for cooking has decreased, although by exactly how much it is difficult to gauge. With over 320 days of sunshine per year (NamibRand Nature Reserve, 2010) it is safe to assume virtually all cooking for the lodge could be done on the solar cooker.

Figure 4-1: Solar parabolic dish cooker

4.2.2 Solar systems

The DDL has a 12V pool pump and 12V lighting. The two systems are separate with the direct current (DC) pool pump being driven by three 75W solar panels via a solar pump controller. When there are clouds overhead the pump slows down and during times of sunny skies it operates at full speed. The 12V lighting is powered by two 96Ah batteries which are charged via the same panels. There are 36 five watt LED lights and four 10W spot lights and all of them operate simultaneously when the batteries are fully charged. No 220V facility is offered to clients and in the majority of instances this is readily accepted. Batteries for cameras and cell phones can be charged at the manager's residence.

The DDC has two 12V lighting systems, one that provides light in the kitchen, and one that powers two LEDs in the toilet and shower areas. These lights are very reliable and provide ample lighting.

At the managers residence a single 75 W solar PV panel charges two 96Ah 12V batteries that service the 12V lighting. This lighting system has been deliberately designed as a stand-alone system that is independent of the generator / battery bank combination so that lighting is not dependent on the primary power source, a 2V battery bank charged via PV panels and the generator. See Appendix D for a diagram of operation. The managers residence also has emergency 220 V back up power provided by a single 12V 96Ah battery which is charged from the 2V battery bank or alternatively the solar PV panel that supplies power to the 12V lighting system and is used to power the cell phone and the satellite phone and internet facility through a 400W 12V to 220V inverter, diagrammatic details of which are provided in Appendix E. This system is in place for emergency use: should either the charger or the inverter from the primary battery bank be faulty there will be back-up 220V power for emergency phone calls - Appendix E provides a detailed breakdown of the system.

A solar photovoltaic array of twelve 75W panels provides charge for the 18 by 2V batteries that form the 36V battery bank. The solar panels are about 15 years old but still provide reasonable charge levels. The batteries do however still need supplementary charging from the generator.

Four 75W solar PV panels power a 12V DC submersible pump which delivers around 700 litres of water per day.

4.2.3 Toyota Land Cruiser

The game-viewer, a Toyota Land Cruiser, is used primarily to take guests on game drives, once per month to run recyclables, primarily glass and tin, off the property, and collect LPG and bulk diesel: a distance of around 500km per month for town trips. Altogether the Land Cruiser covers an average of 19 000km per year and at 10km/L uses 1 900 litres of diesel fuel, around 68% of which is used on site at the DDNR. The UK government emissions rating for the Land Cruiser is 360g/km (DirectGov UK, 2011a) equates to the vehicle producing 9 630kg of CO_2 per annum.

Electric vehicles are gradually becoming more widely available. Land Rover South Africa, in conjunction with Barker Performance Products, has developed an all-electric game viewer specifically for sale to the game lodge market (LRSA, 2011; Barker Performance Vehicles, 2011). This zero-emission Land Rover has a range of 80km with a 20km reserve (LRSA, 2011; Barker Performance Vehicles, 2011) and would be ideal for use on the gentle terrain and in the abundant sunshine of the DDNR, effectively replacing the Toyota Land Cruiser as a game viewer. Charging would be via solar panels and the currently installed charger thus there would be no need for additional infrastructure. Cliff Barker, owner of Barker Performance Products, expects retail prices to start at around N$400 000 (personal communication, Baker, C., 15 October 2011).

Figure 4-2: Electric game viewing vehicle
(Barker Performance Vehicles, 2011)

Replacing the Toyota Land Cruiser with an electric Land Rover would neutralise the carbon emissions of the game viewing activity and reduce overall diesel consumption by 1 292 litres per annum, which at an average pump price of N$9.05 over the last year would result in a saving of N$11 718. Seeing as the Land Rover of Barker Performance Products would require maintenance direct costs are likely to remain similar and the offset would be limited to the fuel savings. This means that the Baker Land Rover would take about 36 years to generate a return on the investment excluding depreciation and amortisation: less than ideal.

A second consideration that needs to be taken into account is that the Land Cruiser has been extended in order to accommodate extra seats and in its current configuration can carry 18 clients and a driver (four rows of seats with four clients in each and three in the front). This is not a standard configuration for game viewers and the Baker Land Rover is anticipated to hold the industry standard 10 clients. In order to accommodate the extra clients at least N$ 50 000 would have to be spent on reconfiguring the Baker vehicle which would drive costs higher and returns lower.

Replacing the Land Cruiser with a cheaper petrol or LPG driven 4X4 is not considered an option and the reasoning is as follows: The Land Cruiser is 13 years old and has almost 400 000km on the odometer and in that time it has been well maintained and is generally trouble free. To sell the vehicle may realise N$ 100 000 in income that can be offset against the cost of a newer vehicle, and petrol driven vehicles can be fitted with tanks and injection systems where diesel ones cannot (personal communication, Mendonca, A.,15 October 2011), but the cost purchasing and converting a newer petrol or LPG driven vehicle would still be in the region of at least N$ 300 000. If the net cost to replace the Land Cruiser were N$ 200 000 the direct fuel saving would see a return in around 18 years, and if one adds to this the carbon rucksack of extracting the fossil fuels and manufacturing and transporting the LPG, the manufacturing and conversion of the vehicle, and the risk entailed in swopping out a reliable vehicle with an unknown entity the result is reinforced - replacing the Land Cruiser is not a worthwhile exercise.

4.2.4 Toyota Hilux

The manager's vehicle is a 2006 Model 4.0 L petrol Toyota Hilux used for shopping/grocery trips to Mariental and long trips to Windhoek for administrative purposes. The UK government emissions rating for the Hilux is 305 g/km (DirectGov UK, 2011b). The Hilux travels 31 066km per year, for which it consumes 4 636 litres of unleaded petrol and produces 9 630 kg of CO_2.

Autogas Namibia is based in Windhoek and supplies LPG conversion kits for petrol-propelled vehicles. The owner of Autogas Namibia, Antonio Mendonca, quoted the conversion cost for the Hilux at N$5 000 with an immediate savings on fuel of 20% (personal communication, Mendonca, A.,15 October 2011). Saving 20% of 4 663 litres will result in a fuel saving of 932 litres which at a pump price average over the last year of N$8.78[13] would save N$8 182 in fuel costs and the conversion would thus pay for itself in just under eight months. Autogas has refuelling facilities in Mariental and Windhoek (personal communication, Mendonca, A., 15 October 2011).

The Australian government lists the LPG conversion ratio of CO_2 to be 1.6kg CO_2 emissions per litre of LPG (Australian Government, 2011). After the conversion the annual LPG consumption of the Hilux would be 3 731 litres and the net effect of this exercise is to factor in 5 969.6 kg of CO_2 emissions to the overall GHG equation of the DDNR.

4.2.5 Generator

A 40 kVa generator, wired in single phase, provides 220 V AC electricity to a washing machine, the 36 V battery bank, a 1.1 kW centrifugal borehole pump, a 2.2 kW centrifugal reservoir pump that pumps water to the campsite and lodge, two 220 V electric geysers, and six wall socket outlets for various power tools and general use.

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[13] Refer appendix I.

Figure 4-3: Battery bank and generator

Largely due to the extended running times the generator at the DDNR currently accounts for 30% of fossil fuel use. The generator runs for an average of 4.55 hours per day and has been measured to use around two and a half litres of diesel per hour. This is 4 154 litres of diesel in the year under review.

The generator is maintenance intensive with N$24 470 being spent on servicing and maintenance over one year. At an average diesel price of N$9.05 over the last twelve months (Ministry of Mines and Energy 2011) the fuel costs of running the generator equate to N$37 606 which together with maintenance costs equate to a combined total cost of N$62 077 per annum. Generator operating times and the cost of the maintenance is summarised in Appendix F and G and a full costing analysis can be found in Appendix H. The generator's total fuel-derived CO_2 debt is in the region of 11 tonnes per annum. Replacing the appliances that the generator provides energy for and the subsequent partial phasing out of the generator is thus central to balancing the carbon accounts of the DDNR.

Pumps: Grundfos pumps can operate off 220V or 12V and are capable of pumping to the required specifications. The two 220V pumps can be replaced with Grundfos solar pumps at a fully installed cost of N$50 820 (personal communication, Afro Pumps, 12 October 2011).

Solar water heaters: SolSquare Namibia can supply two good quality solar water heaters capable of withstanding the environmental and weather extremes experience at the DDNR at a fully installed cost of N$26 841 (personal communication, SolSquare Namibia, 11 October 2011).

Fridge/freezer: Two 125-litre National Luna 12V DC fridge / freezers at the managers house would provide sufficient capacity and can be supplied with power from the existing panels and charge controller, N$27 200 (personal communication, National Luna, 13 October 2011).

The initial combined cost of the new equipment is N$104 861. The generator could be kept for essential and intense power applications such as drilling, welding, supplementary battery charging on overcast days and using the washing machine. Running time could be reduced to no more than an estimated one hour per day, probably less, which will reduce annual running costs from N$62 077 to N$13 643, an annual savings of N$48 443 and a return on investment in two years.

With the annual fuel consumption reducing from 4 154 litres to 912 litres, CO_2 emissions would be reduced from 11 008 tonnes to 2 416 tonnes of CO_2 per year.

4.2.6 John Deere gator

The John Deere gator is a 2004 model three cylinder diesel utility vehicle with a 0.66 litre displacement that is used by staff to service the campsite and lodge. With an average operating time of 0.37 hours per day and a fuel efficiency of 2.5 litres per hour the gator uses 337 litres of diesel per year and produces 894 kg of CO_2.

Considering the use derived from the vehicle, as well as the cost of replacing it with something similar in an electric guise, it is worth keeping. It does however contribute to the overall carbon debt of the DDNR and as such forms part of the carbon cost of operating the reserve.

4.2.7 LPG

Eight 18kg LPG bottles provide hot water at the campsite (two LPG geysers), hot water in the DDL rooms and kitchen (six LPG geysers), cooking and cooling facilities at the lodge, and cooking facilities at the staff house and manager's house.

The DDNR uses around two kilograms of LPG daily at a cost of just over N$1 000 per month details of which are in Appendix K. The fridge and stove at the lodge are plumbed to the same 18kg bottle of LPG and together are the largest consumers of LPG on the DDNR, 745 grams of LPG each day - ref Appendix L. This equates to a cost of N$430 per month or 46% of the LPG used at the DDNR.

Replacing the LPG fridge at the lodge with a 12V DC National Luna 90 litre fridge/freezer would cost N$12 750 (National Luna, 2011) with no additional costs for panels and charge controllers since these are already present and this equates to a payback period of 30 months and a 741kg reduction in CO_2 emissions.

4.2.8 Annual CO_2 debt of the DDNR

As per the ISO Standard framework discussed in point 2.7:

The organisational boundary of the DDNR can been defined as activities on the reserve itself as well as all supply chain and logistical activities (staff leave times etc) that contribute to the running of the reserve. Using the generator and transport to and from the DDNR are largest contributors to the carbon debt of the reserve.

The GHGs have been defined to be LPG and CO_2, while CH_4 and N_2O have been excluded since emissions figures are not available and their production depends on chemical reactions which are highly variable and dependent on engine condition, exhaust temperatures and the condition of catalytic convertors (Lipman & Delucchi, 2002). CH_4 and N_2O figures are also not used when calculating carbon tax requirements in South Africa, the UK, and Australia. For this reason the measurements are in CO_2 and not CO_{2e} as required by the ISO reporting requirements.

A base line of one year has been used to calculate all figures. In some case measurements were taken over a period of less than one year (for example, fuel cost calculations) and in others it was longer than one year (LPG use), but in all cases figures were adjusted to represent a period of 365 days.

Management and procedural interventions were not quantified but discussed as a part of the greater requirement for systemic change per point 4.3 on the next page. Energy demand was quantified, fuel switching was considered, and technological improvements are discussed in detail.

In summary, the five carbon emitters on the DDNR combined produce just over 30 tonnes of CO_2 per annum, as per table 4-1 on the next page. Fuel use figures for each motor and a ULP and diesel costing for one year can be found in Appendix I and J.

	Litres ULP	Litres diesel	Km/yr	kg CO2/L	kg CO2/km	kg CO2/yr
John Deere Gator		337.44		2.65		894.21
John Deere generator		4154.30		2.65		11008.89
Toyota Hilux	4636.83		31066.73		0.31	9630.69
Toyota Land Cruiser		1905.07	19050.72		0.36	6858.26
LPG						1765.43
	4636.83	6396.81	50117.46			30157.05

Table 4-1: Current annual CO_2 debt of DDNR

4.3 Organisational change

Technological fixes can be construed as an easy option since they provide simple-to-understand solutions to the problem of inefficiencies. But changing the way systems are configured can also lead to considerable savings, although somewhat challenging to quantify.
Efficiencies at the DDNR revolve around cost. Groceries are the single highest cost-driver on the reserve with a direct monthly spend of N$6 873. There are also secondary costs that need to be taken into account such as fuel for shopping and the time spent doing so. Diesel is the second highest cost-driver with a monthly spend of around N$6 600 – Appendix N gives a detailed breakdown of the different balance sheet costs. Diesel is used for pumping and heating water, for charging batteries and for driving around, so any fuel based efficiency gains would first be centred on these activities.

4.3.1 Why some things are a challenge to change

It may seem an obvious question to ask why, if there are Drifters tours passing through the property on a weekly basis, the tours do not supply consumables to the DDNR? There are a number of reasons for this.

Firstly, the way the overland trucks are configured is a problem. When the vehicle is full or almost full then there is no space for extra shopping for another location. Small items that are important to the lodge such as filters for the generator are put on the trucks from time to time but large and bulky groceries such as pockets of onions and potatoes can only be transported with difficulty.

Secondly, the full time labourer at the DDNR needs time off, and in order to get this he has to be driven into Maltahöhe, 125km away. His schedule is such that he gets two weeks off and six weeks on, so at least every second month two trips are made to town. The DDNR is remote and while on the odd occasion it is possible to share transport with a neighbour there are not many neighbours so this seldom works out. Due to the configuration of the itineraries it is not possible for him to catch a lift with the overland trucks.

Thirdly, the truck on the CV tour comes to the DDNR from Cape Town and any shopping would have to come from there. Since this is a full week before the CV arrives at the DDNR it precludes anything other than dry goods being delivered. The tour does not pass through any shopping centres or significant towns en route to the DDNR. The NAM tour departs from Windhoek and could bring some fresh produce and indeed the guide on the NAM tour often does limited shopping for the DDNR, but the gaps between trips on the NAM tour is two days and in this time the guide has to complete servicing the truck and do all of his or her own shopping and more often than not is too busy to pay much attention to the DDNR.

And lastly, the Land Cruiser can carry a maximum of 400 litres of diesel which lasts around three weeks which means a trip into town to collect diesel. If the timing of the trips is correctly coordinated staff drop offs, diesel, LPG and shopping can all be done as a once-off trip every two to three weeks.

4.3.2 What can easily be done at the DDNR

Expanding the vegetable garden to reduce dependence on bought vegetables would not result in significant cost implications and could have significant savings potential. It would also be possible to look at the incorporation of other food sources into this garden such as chickens and perhaps livestock on a small scale, so as to not detract from the overall wildlife experience.

The sustainable utilisation of wildlife will reduce dependence on bought meat, but would require investment into meat processing equipment, a suitable, silenced, firearm, and larger freezing capacity. Up until this point the harvesting of meat has been restricted to using fresh carcasses from animals that have been injured or caught in the fences. But meat is expensive and the lodge uses lots of it so investing in a meat processing facility would certainly prove viable.

Redesigning the water reticulation at the manager's residence and the lodge to allow grey water to flow to trees and not into a soak-away would negate the need to water the trees, reducing pumping time and diesel use. Reducing lawn coverage at the lodge and replacing it with a water-wise indigenous garden would save at least 1 000 litres of water per day in summer, reducing diesel consumption and wear-and-tear on equipment.

And lastly, redesigning the internal road network between the lodge, the campsite, and manager's residence and the game viewing areas would reduce the distances that need to be driven between locations and thus reduce diesel consumption and wear and tear on vehicles.

4.3.3 Systemic group-level change

At the ownership level of the Drifters group of companies and in the context of owning 14 accommodation establishments that each have their own carbon footprint an audit of each of the lodges' carbon footprint could be done and these could be examined holistically. If some technological interventions are common between lodges better prices could be negotiated for electric vehicles for example, and payback periods and investment required could be correspondingly reduced. It is also possible that centralised purchasing of dry goods may result in better prices being negotiated and if new trucks, which are purpose built at Drifters own workshop, incorporated extra storage, perhaps even at the cost of a client's seat, this could translate into the delivery of dry goods with a corresponding cost saving.

An ethos of sustainability could be taught and encouraged throughout the organisation. Each accommodation establishment, where possible, could, for example, be encouraged to grow their own vegetables, reorganise water reticulation away from a linear system toward a closed loop cycle where grey water is used for watering plants and lawns.

Travel agents and wholesalers, the critical link in the chain for a tour operator, need to be canvassed for resistance or acceptance levels with regard to a one-off VER payment and methods of implementation need to be investigated. It would not be an exaggeration to say that if there was significant resistance from major suppliers any VER scheme would not work.

5 Summary of results

5.1 Offsetting

It is clear that some technological interventions are more carbon reducing and cost effective than others. The most carbon and cost effective intervention is the conversion of the Toyota Hilux to LPG with a payback period of eight months and a CO_2 saving of 3 660.4kg. The second most effective intervention is replacing the appliances that the generator provides power for with RETs and scaling back on generator use: two years payback with a saving of 8 952kg of CO_2. Replacing the LPG-driven fridge at the lodge is less cost effective, and the least cost effective solution is the replacing the Toyota Land Cruiser.

If all of the interventions were to be applied there would be potential savings of 65% of CO_2 (refer to table 5.1 below) but, primarily because of the Land Cruiser, the payback period is long and the full suite of interventions is thus not viable.

Intervention	Cost N$	Saving N$/yr	Payback	Current kg CO_2	New kg CO_2
Toyota Hilux					
LPG installation	5000	8182	8 months	9630	5969
Generator					
2 X Grundfos pumps	50820				
2 X SWH	26841				
Fridge / freezer	27200				
	104861	48443	2 years	11008	2416
LPG					
Solar fridge	12750	5160	2½ years	1765.43	0
Toyota Land Cruiser					
Replace with EV	400000	11718	20-30 years	6858	2195
	522611	73503		30157.05	10580
				DDNR saving	**65%**

Table 5-1: Maximum possible savings at maximum cost

However, if converting the LPG fridge to solar and replacing the Toyota Land Cruiser are removed from the equation, then the interventions look more attractive. A more focussed strategy would embrace two interventions and result in a payback of 23 months with an overall reduction in carbon intensity at the DDNR of 41%, as per table 5.2 below.

Intervention	Cost N$	Saving N$/yr	Payback	Current CO_2	New CO_2
Toyota Hilux					
LPG installation	5000	8182	8 months	9630	5969.6
Generator					
2 X Grundfos pumps	50820				
2 X SWH	26841				
Fridge / freezer	27200				
	104861	48443	2 years	11008	2416
	109861	56625	2 years	20638	8385.6
				direct saving	**41%**

Table 5-2: Targeted interventions

When factoring in VER payments from an emissions-reduction scheme with a potential N$36 180 per annum the overall cost of change of the two most effective interventions is reduced from N$109 861 to N$73 681. The payback factor improves by 30% and the interventions are paid for in around 16 months as opposed to just over 23 months.

Is a VER project a viable option at the DDNR?

While the willingness to pay a VER is very significant, at an average of 73%, the administration involved in operating the scheme is virtually a full-time job and average payback levels are relatively low. The largest group surveyed, 49%, opted for a payment of somewhere between N$20 and N$50. With 1 055 clients in the last year, processing 770 payments with 385 of them being in the region of N$20 it may not make financial sense. If a total projected collection of N$36 180 did materialise, most of this benefit could be lost by paying an individual to administer and control the payments.

If however the payment was instituted at group level, with some 3 000 clients and a potential N$ 103 000 in VER payments the sums start to make more sense. While still a small amount in terms of the overall turnover of the group a combination of a VER payment as well as targeted DSM interventions could end up making a significant impact on the way business is conducted.

5.2 Further research

The major shortcoming of this research is that it does not quantify the potential savings from potential systemic change especially with regard to the role that Drifters tours could play in generating savings. Transport is the primary cost drive and routing and scheduling needs to be better organised and communicated and the movement of staff and products needs to be regulated within the set schedule.

The relationship between the agent or wholesaler and the service provider needs to be clarified and potential resistance to a voluntary payment needs to be gauged and the administrative burden of dealing with a VER scheme also needs to be accounted for. If there is significant resistance to a VER scheme it is unlikely to work.

During the course of the research it became clear that Europeans are in general more environmentally aware than Southern Africans. Recycling is a legislated norm and fuel efficient cars are not derided as being small and dangerous. Southern African tourism product owners not only need to change business processes and become more efficient, they also need to take into account the perceptions and values of their clients. The marketing mileage that could be gained from the implementation of a VER may, to an extent, sustain the intervention.

It is clear that the focus of international tourism should be the carbon intensity of long-haul flights. Product owners can be as environmentally friendly as possible, but at some point the desire that a carbon-conscious tourist fulfils by flying to destinations halfway round the globe is going to be offset by concern about the effect that it is having on the global environment: it is in the interests of all operators that the way the air transport industry operates needs to be revolutionised.

While conducting the survey and researching the carbon accounts of the reserve it became obvious that there was an underlying factor that bothered respondents: an offset scheme only qualifies for CER status if it can be proven that the development would have happened regardless. For example, if a run-of-river generating station is built in Borneo did the community it serves really need the power? If yes, then the energy is now clean energy instead of being provided by a diesel powered electric generator. But the line becomes blurred when a VER is injected into the balance of a for-profit organisation such as the DDNR and clients become concerned about the financial long term benefit that the organisation would derive from the payment of a VER. Any VER scheme would need to be conscious of this and be careful about the manner in which the scheme is promoted and the way in which the funds are used.

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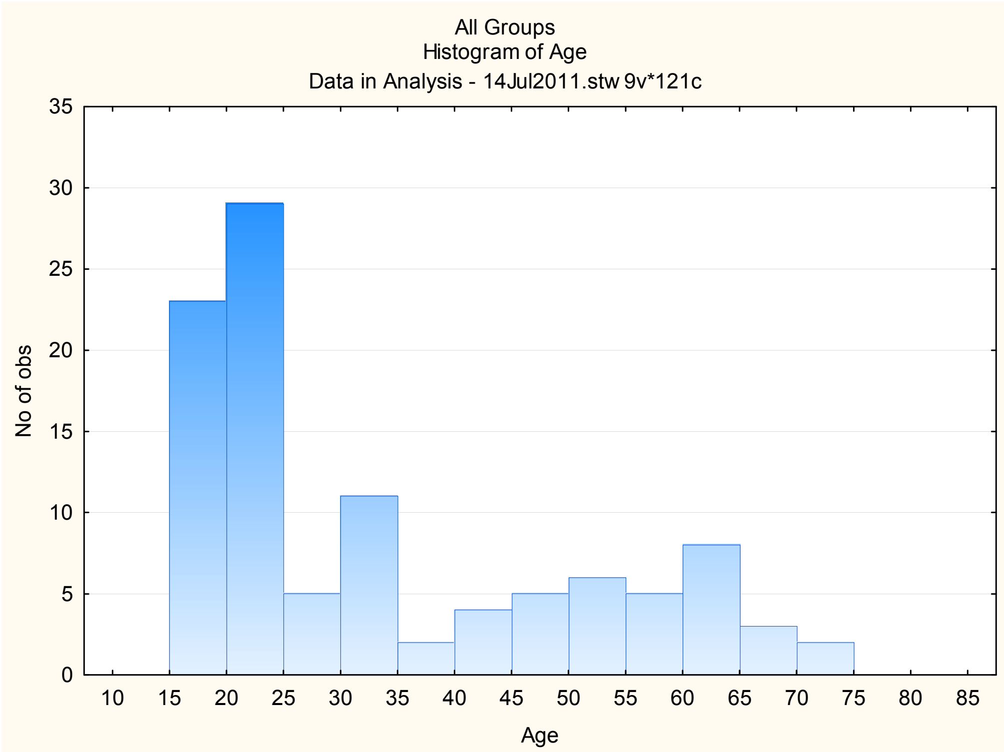
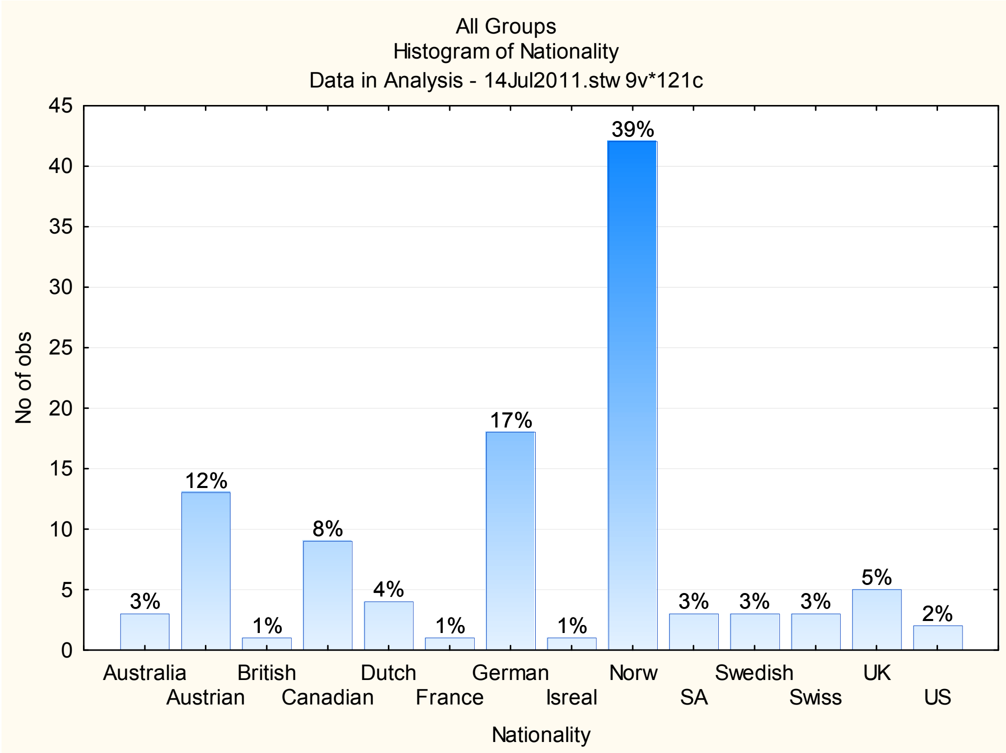
7 Appendices

7.1 Appendix A: Combined results of questionnaires at DDL and DDC: 'All Groups'



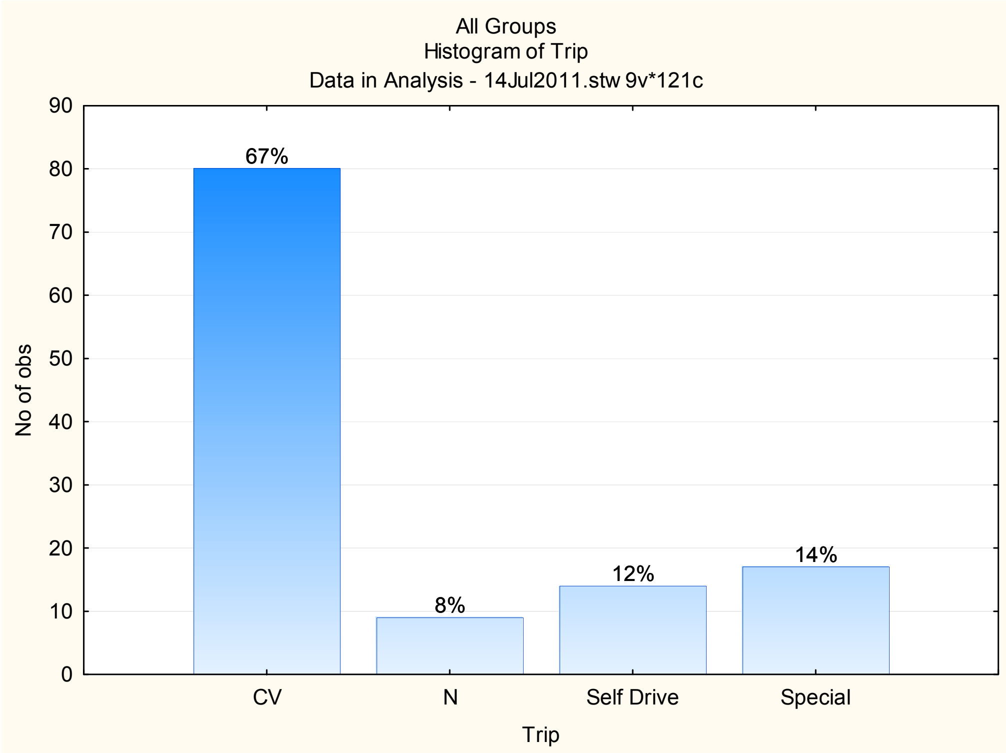
All Groups
Descriptive Statistics (Data in Analysis - 14Jul2011.stw)

Variable	Valid N	Mean	Confidence - - 95.000%	Confidence - 95.000%	Median	Minimum	Maximum	Lower - Quartile	Upper - Quartile	Percentile - 10.00000	Percentile - 90.00000	Std.Dev.
Age	103	34.27184	30.95906	37.58463	25.00000	18.00000	75.00000	21.00000	48.00000	19.00000	63.00000	16.95044



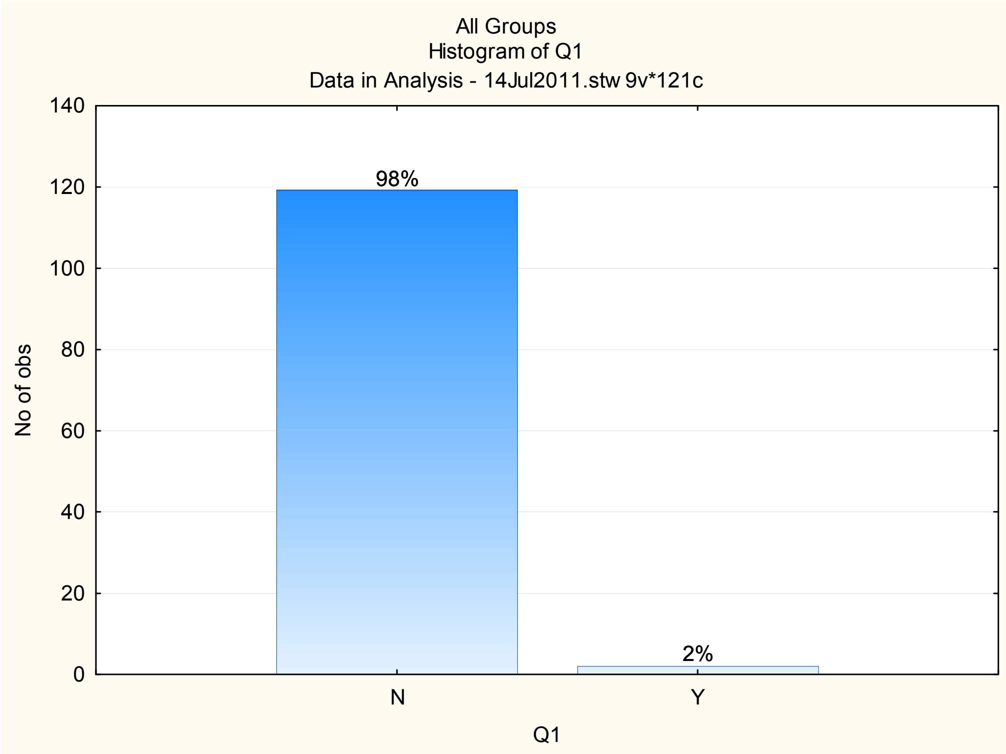
All Groups
Frequency table: Nationality (Data in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative - Percent
Norway	42	42	34.71074	34.7107
Netherl.	4	46	3.30579	38.0165
France	1	47	0.82645	38.8430
Australia	3	50	2.47934	41.3223
British	1	51	0.82645	42.1488
Swiss	3	54	2.47934	44.6281
Israel	1	55	0.82645	45.4545
German	18	73	14.87603	60.3306
UK	5	78	4.13223	64.4628
Swedish	3	81	2.47934	66.9421
Canadian	9	90	7.43802	74.3802
US	2	92	1.65289	76.0331
SA	3	95	2.47934	78.5124
Austrian	13	108	10.74380	89.2562
Missing	13	121	10.74380	100.0000



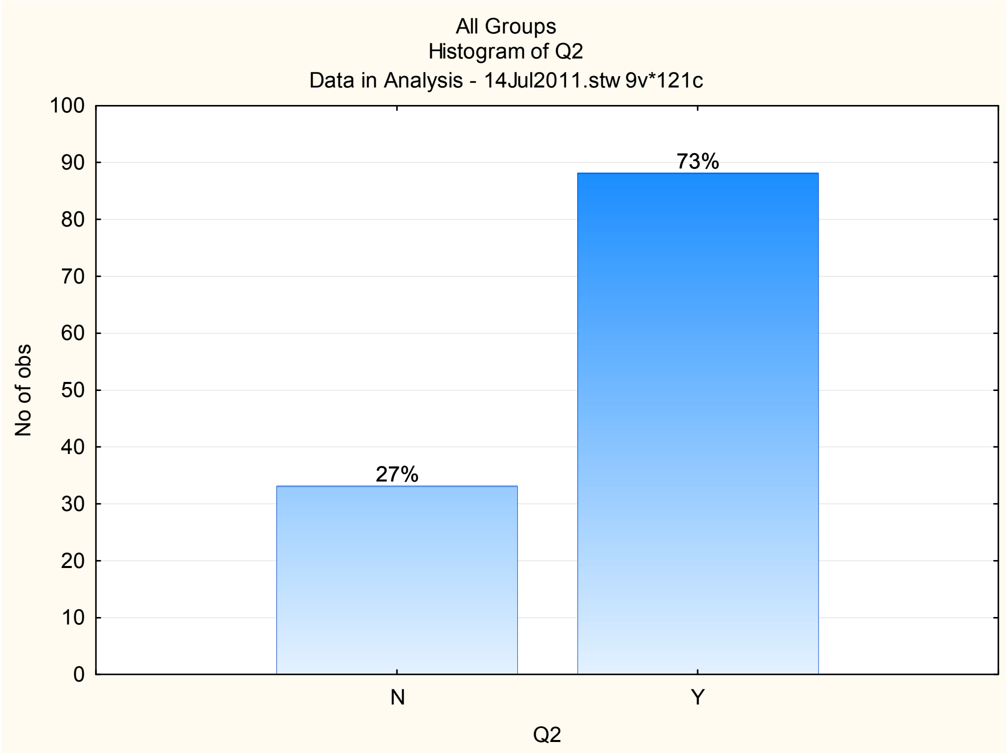
All Groups
Frequency table: Trip (Data in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative - Percent
CV	80	80	66.11570	66.1157
N	9	89	7.43802	73.5537
Self Drive	14	103	11.57025	85.1240
Special	17	120	14.04959	99.1736
Missing	1	121	0.82645	100.0000



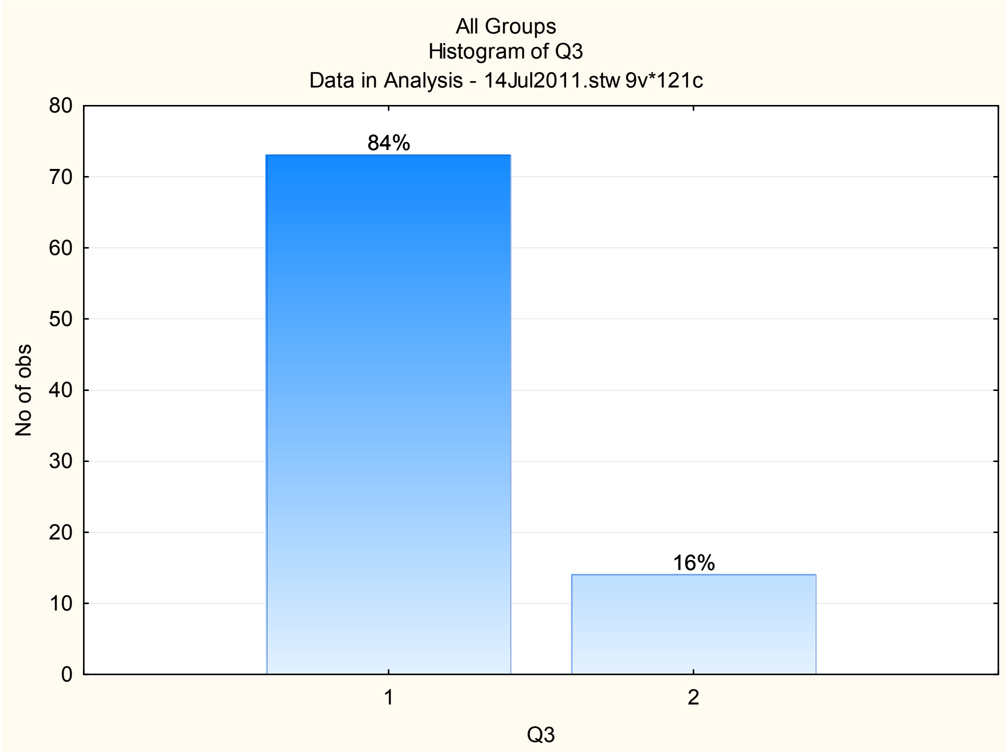
All Groups
Frequency table: Q1 (Data in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative - Percent
N	119	119	98.34711	98.3471
Y	2	121	1.65289	100.0000
Missing	0	121	0.00000	100.0000



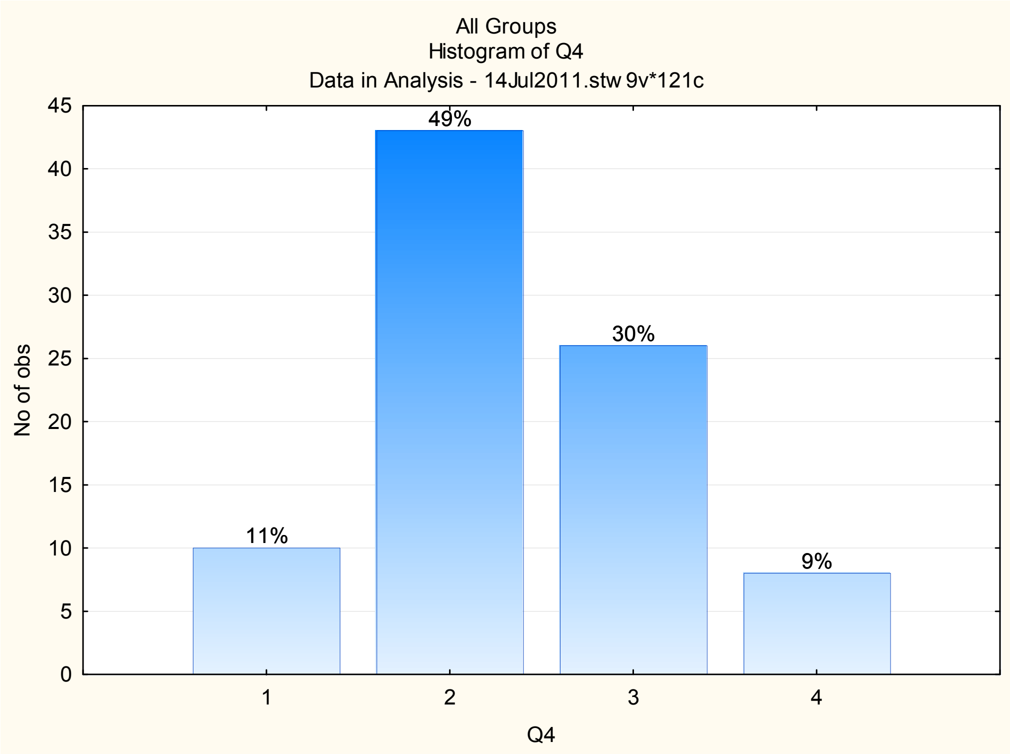
All Groups
Frequency table: Q2 (Data in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative - Percent
N	33	33	27.27273	27.2727
Y	88	121	72.72727	100.0000
Missing	0	121	0.00000	100.0000



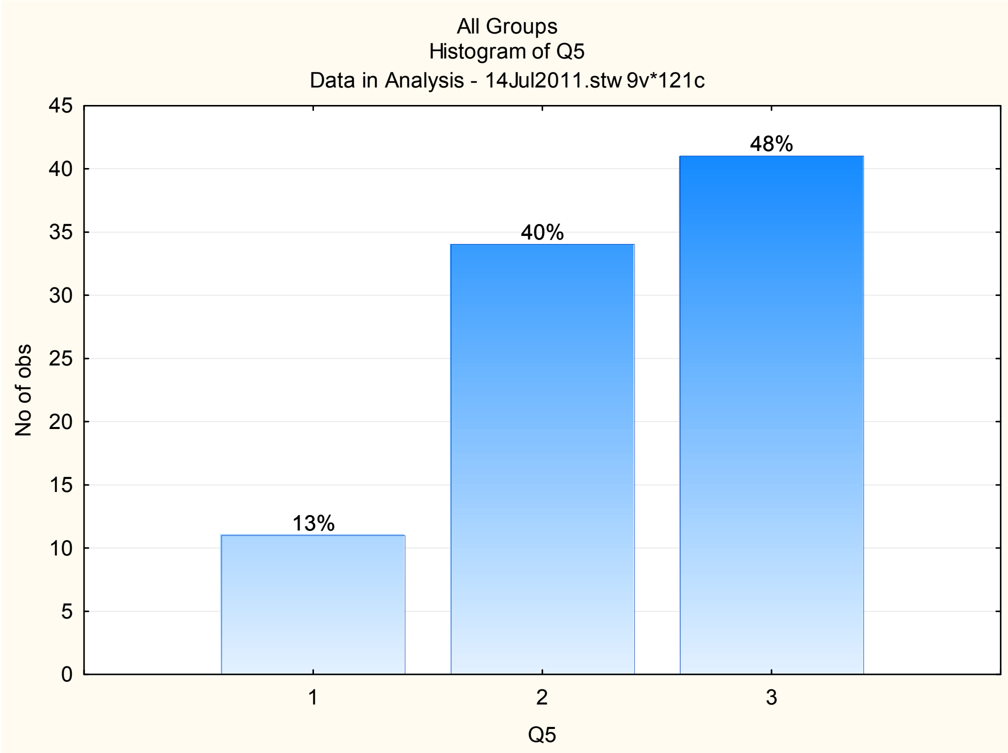
All Groups
Frequency table: Q3 (Data in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative - Percent
1	73	73	60.33058	60.3306
2	14	87	11.57025	71.9008
Missing	34	121	28.09917	100.0000



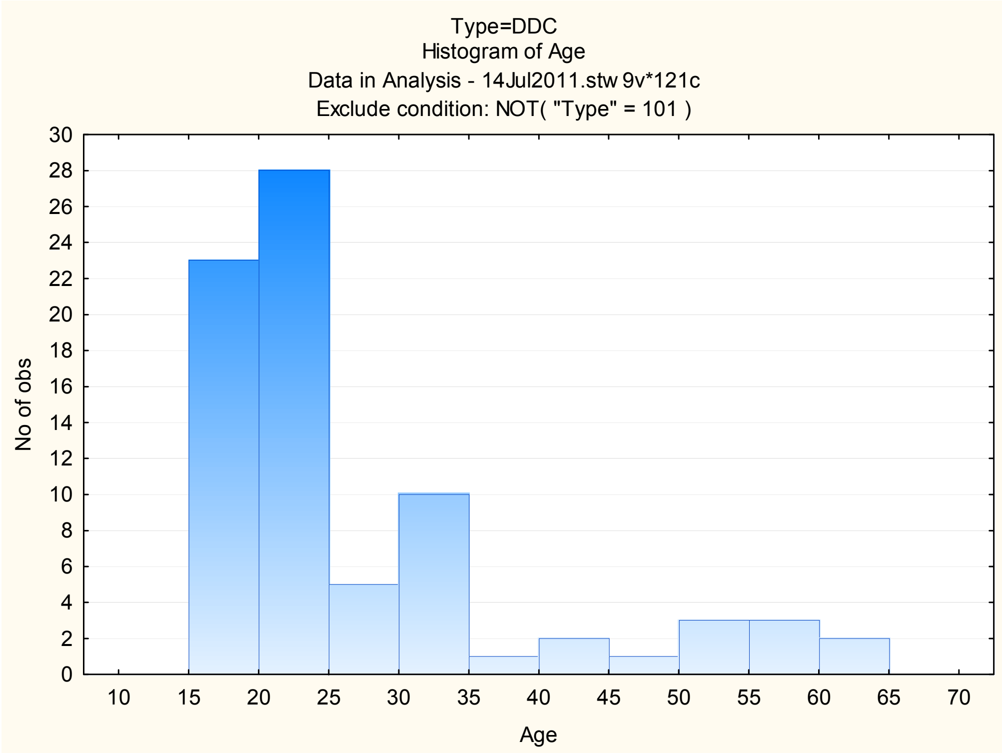
All Groups
Frequency table: Q4 (Data in Analysis - 14Jul2011.stw)

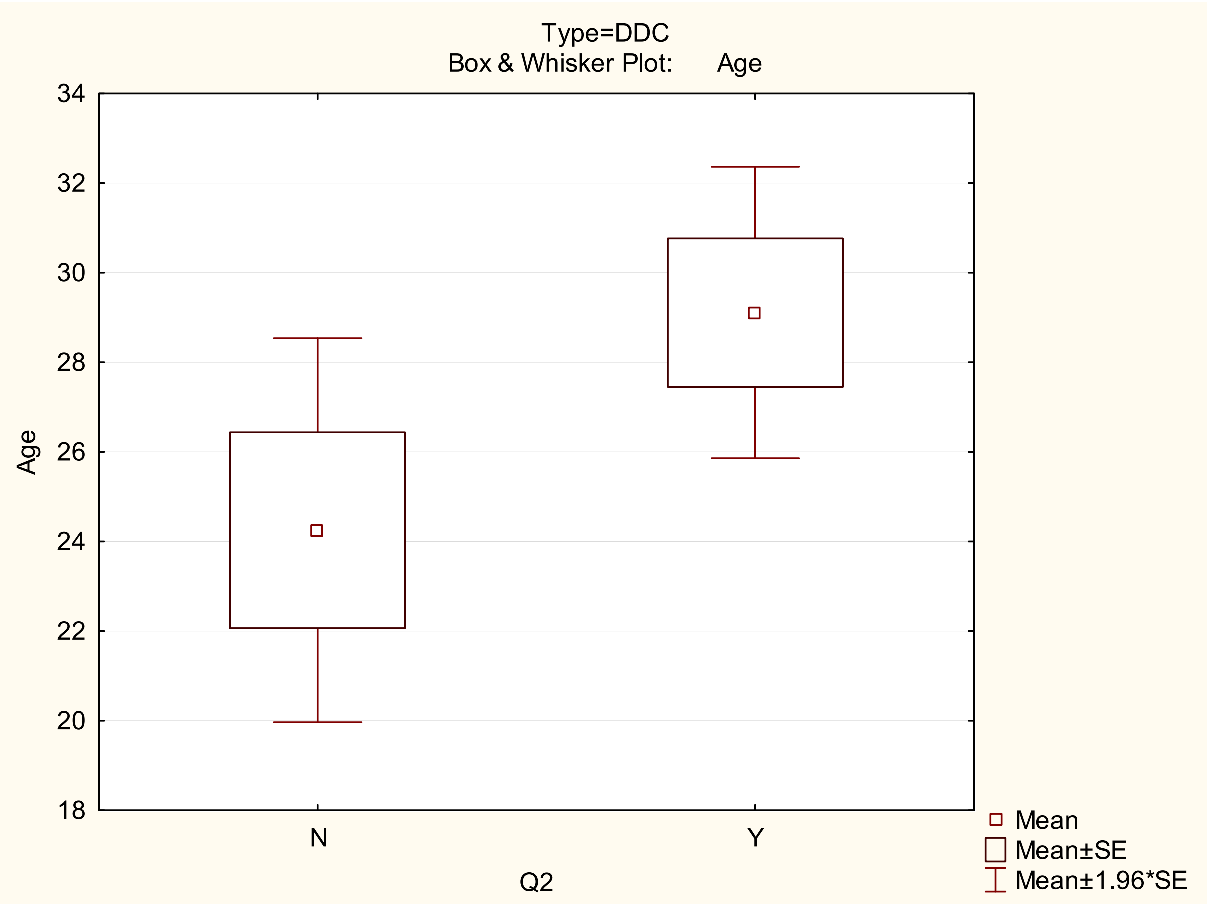
Category	Count	Cumulative - Count	Percent	Cumulative - Percent
1	10	10	8.26446	8.2645
2	43	53	35.53719	43.8017
3	26	79	21.48760	65.2893
4	8	87	6.61157	71.9008
Missing	34	121	28.09917	100.0000

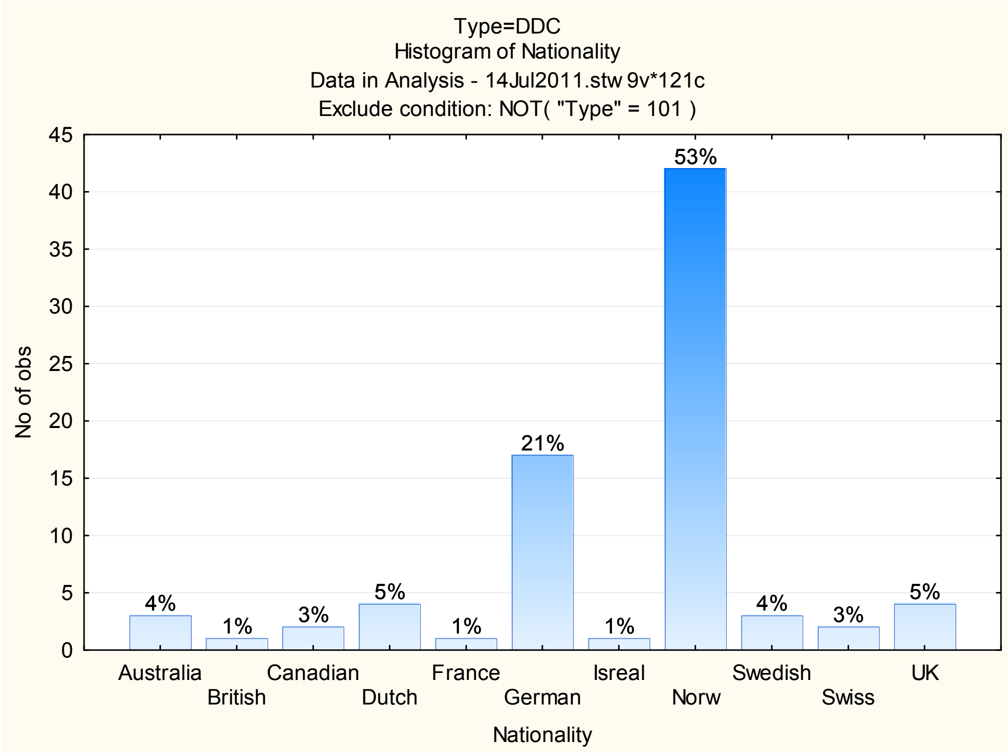


All Groups Frequency table: Q5 (Data in Analysis - 14Jul2011.stw)				
Category	**Count**	**Cumulative - Count**	**Percent**	**Cumulative - Percent**
1	11	11	9.09091	9.0909
2	34	45	28.09917	37.1901
3	41	86	33.88430	71.0744
Missing	35	121	28.92562	100.0000

7.2 Appendix B: Drifters Desert Camp

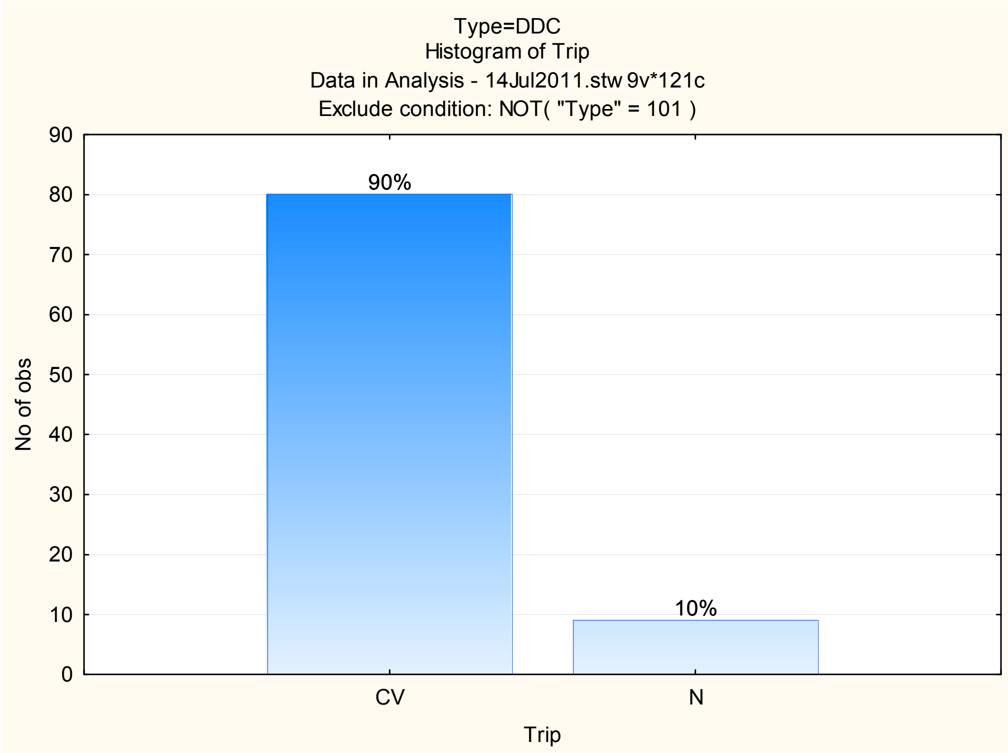






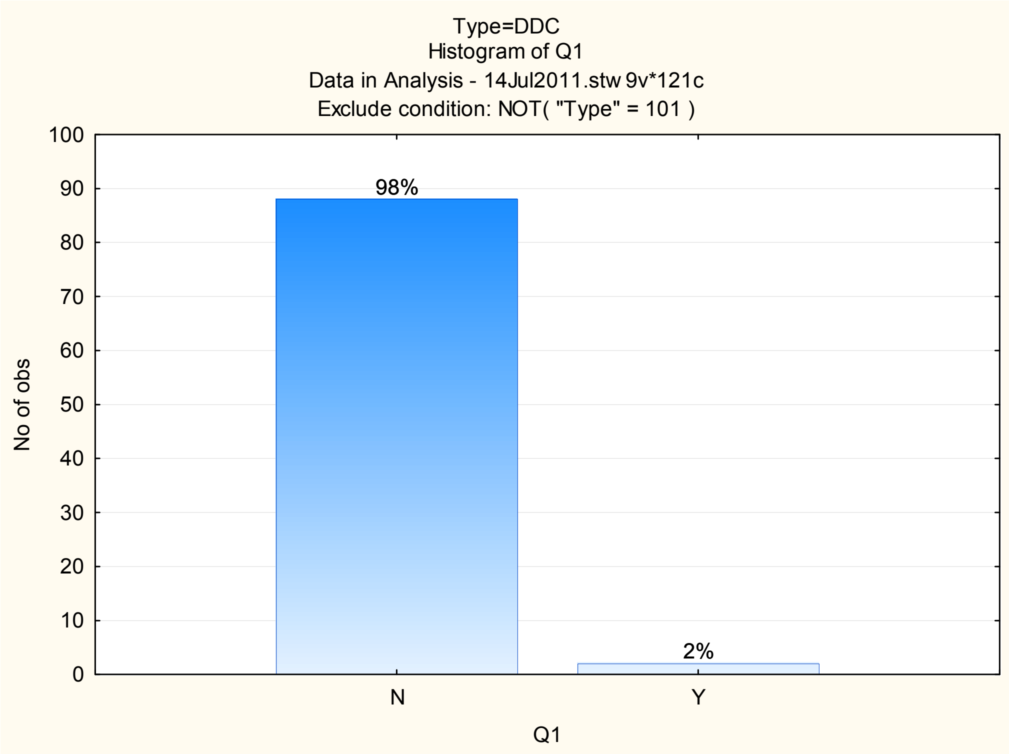
Type=DDC
Frequency table: Nationality (Spreadsheet in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative - Percent
Norway	42	42	46.66667	46.6667
Holland	4	46	4.44444	51.1111
France	1	47	1.11111	52.2222
Australia	3	50	3.33333	55.5556
British	1	51	1.11111	56.6667
Swiss	2	53	2.22222	58.8889
Israel	1	54	1.11111	60.0000
German	17	71	18.88889	78.8889
UK	4	75	4.44444	83.3333
Swedish	3	78	3.33333	86.6667
Canadian	2	80	2.22222	88.8889
Missing	10	90	11.11111	100.0000



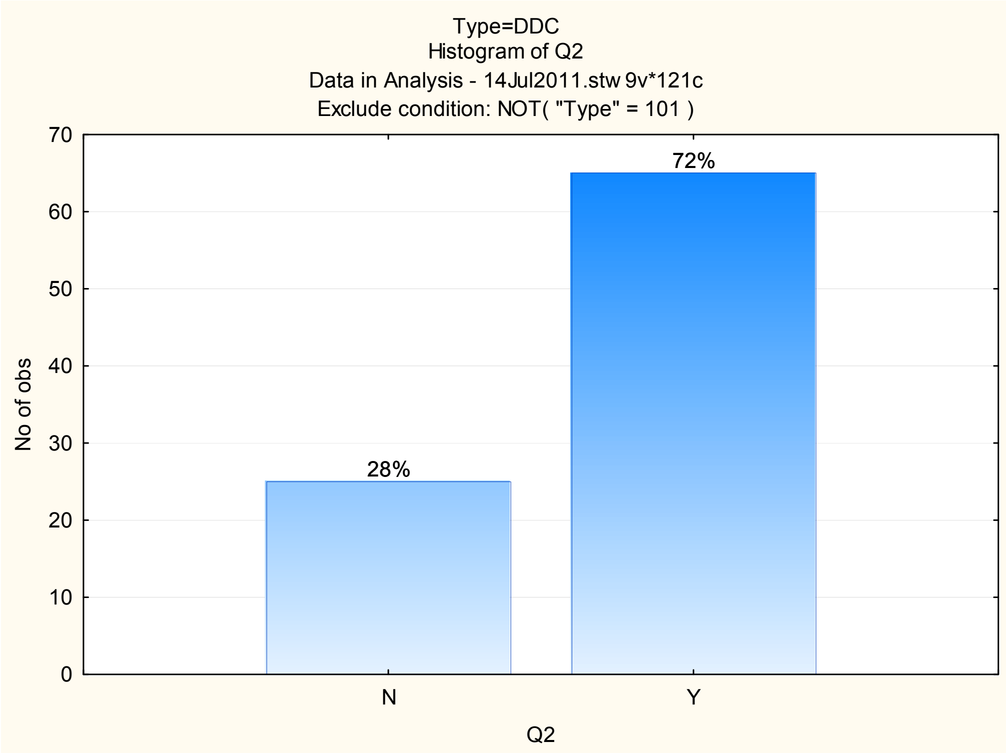
Type=DDC
Frequency table: Trip (Spreadsheet in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative - Percent
CV	80	80	88.88889	88.8889
N	9	89	10.00000	98.8889
Missing	1	90	1.11111	100.0000



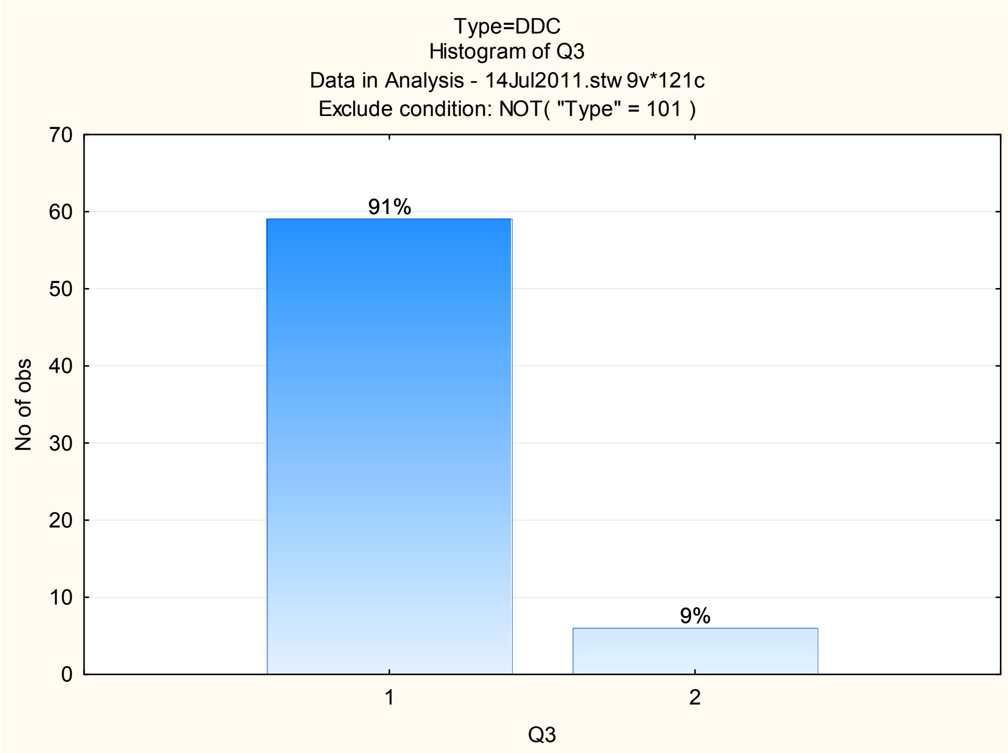
Type=DDC
Frequency table: Q1 (Spreadsheet in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative - Percent
N	88	88	97.77778	97.7778
Y	2	90	2.22222	100.0000
Missing	0	90	0.00000	100.0000



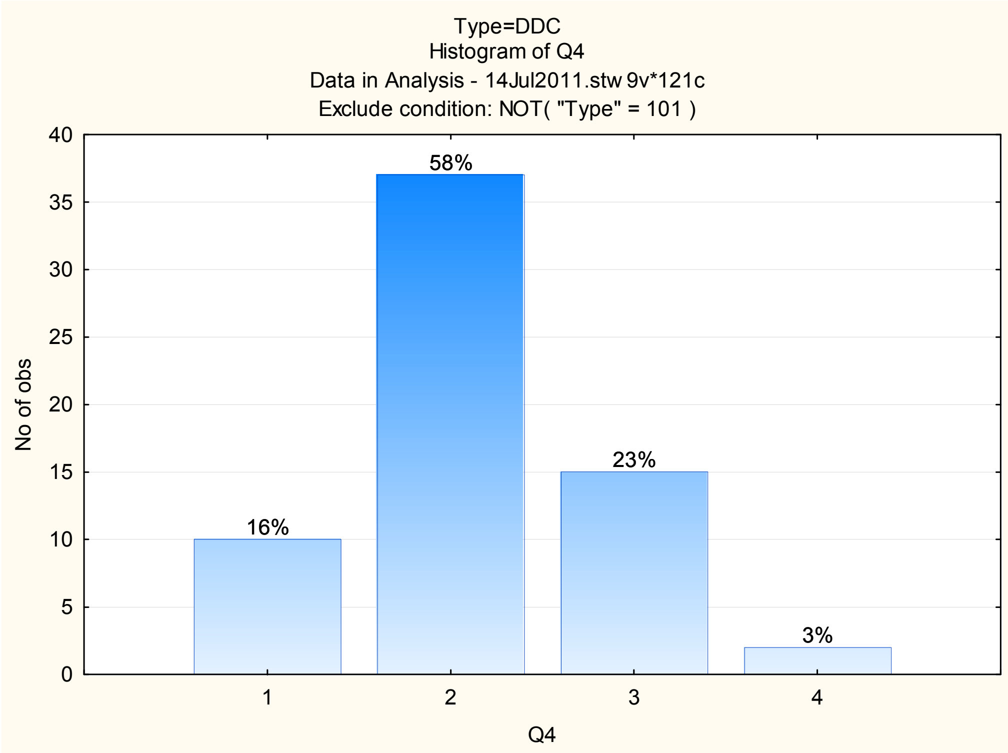
Type=DDC
Frequency table: Q2 (Spreadsheet in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative - Percent
N	25	25	27.77778	27.7778
Y	65	90	72.22222	100.0000
Missing	0	90	0.00000	100.0000



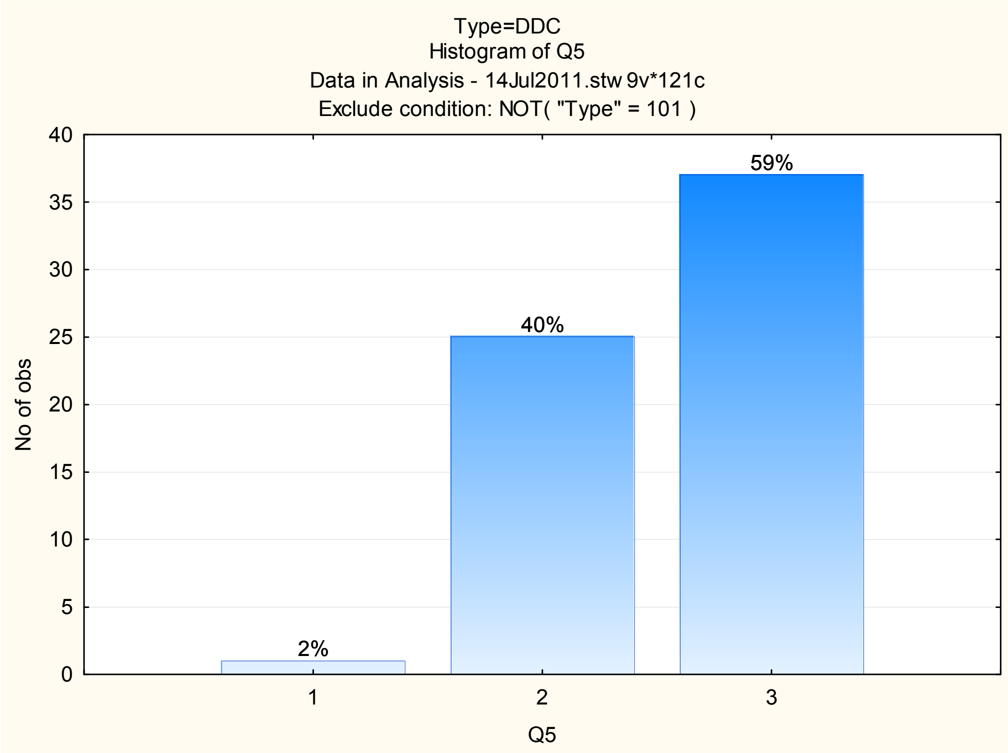
Type=DDC
Frequency table: Q3 (Spreadsheet in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative - Percent
1	59	59	65.55556	65.5556
2	6	65	6.66667	72.2222
Missing	25	90	27.77778	100.0000



Type=DDC
Frequency table: Q4 (Spreadsheet in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative - Percent
1	10	10	11.11111	11.1111
2	37	47	41.11111	52.2222
3	15	62	16.66667	68.8889
4	2	64	2.22222	71.1111
Missing	26	90	28.88889	100.0000



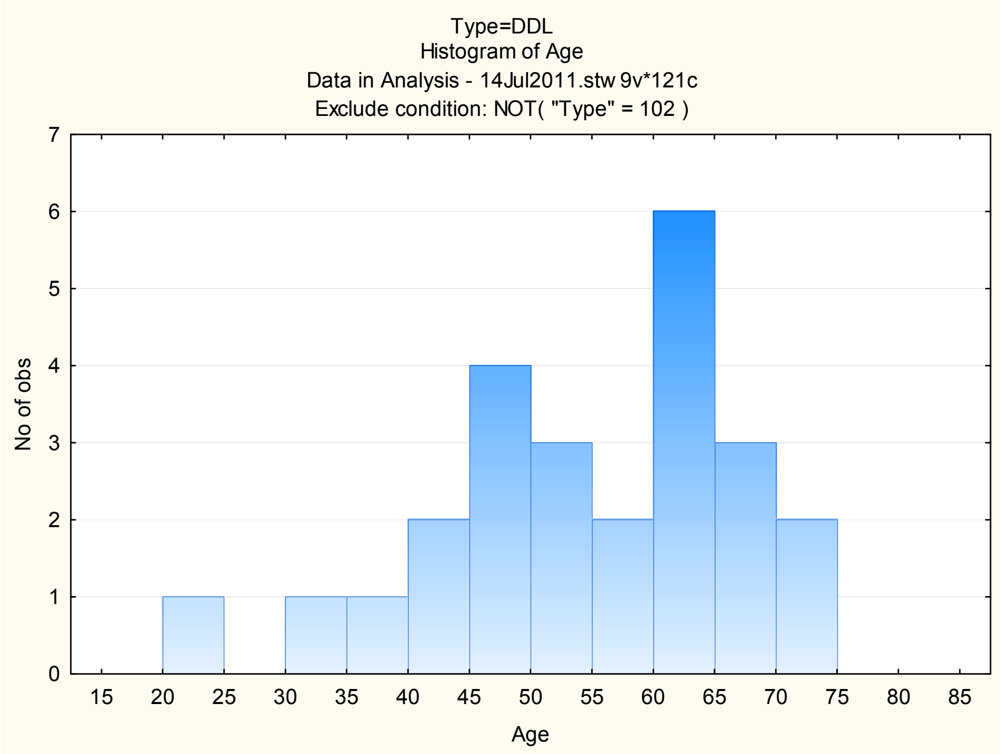
Type=DDC
Frequency table: Q5 (Spreadsheet in Analysis - 14Jul2011.stw)

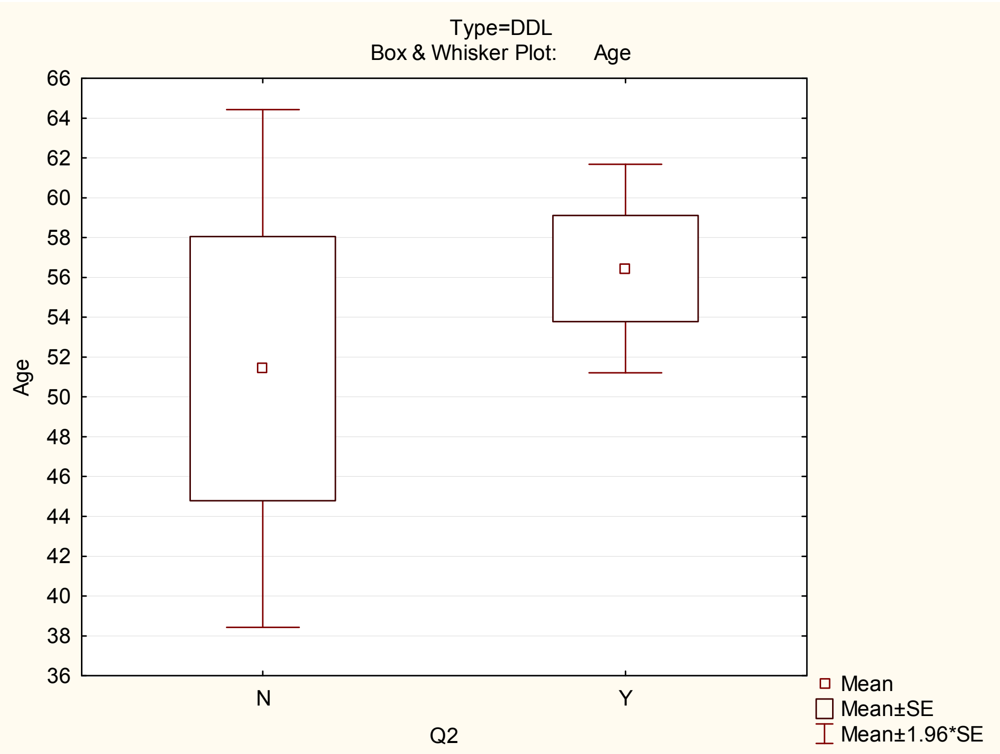
Category	Count	Cumulative - Count	Percent	Cumulative - Percent
1	1	1	1.11111	1.1111
2	25	26	27.77778	28.8889
3	37	63	41.11111	70.0000
Missing	27	90	30.00000	100.0000

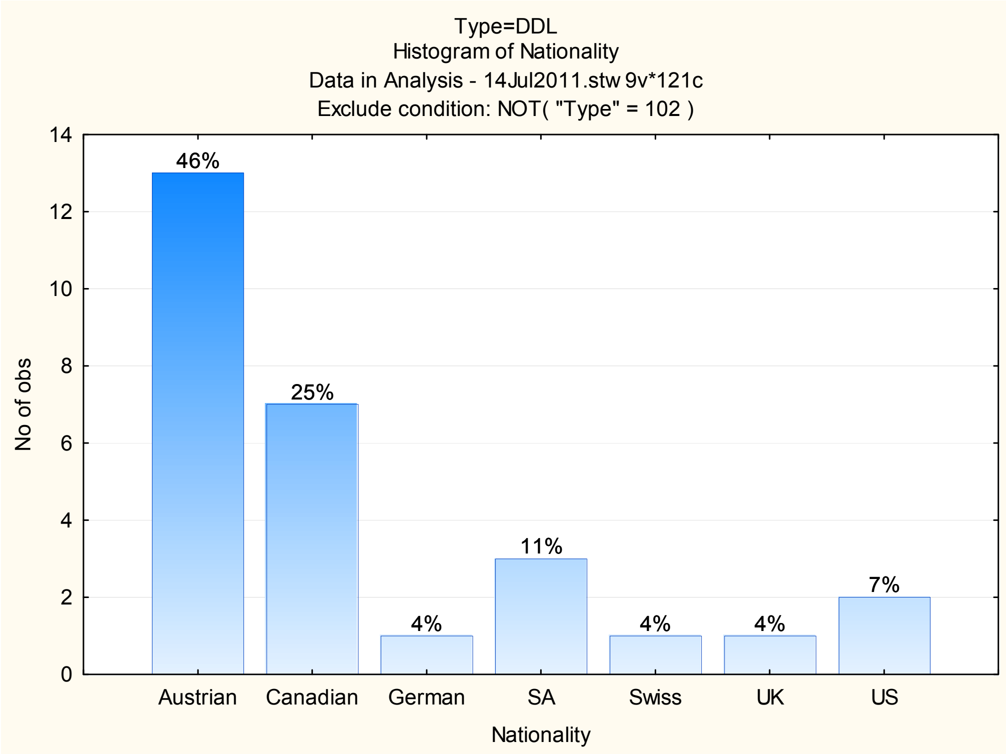
Type=DDC
T-tests; Grouping: Q2 (Spreadsheet in Analysis - 14Jul2011.stw)
Group 1: N
Group 2: Y

Variable	Mean - N	Mean - Y	t-value	df	p	Valid N - N	Valid N - Y	Std.Dev. - N	Std.Dev. - Y	F-ratio - Variances	p - Variances
Age	24.25000	29.11111	-1.68468	76	0.096153	24	54	10.71062	12.18980	1.295280	0.504191

7.3 Appendix C: Drifters Desert Lodge



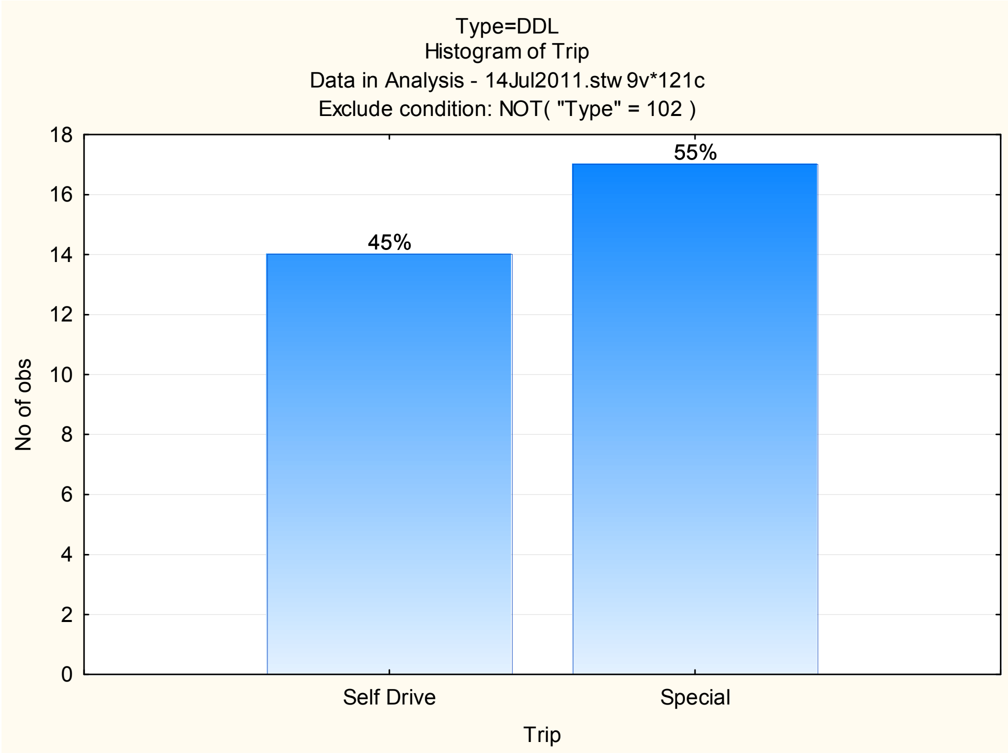




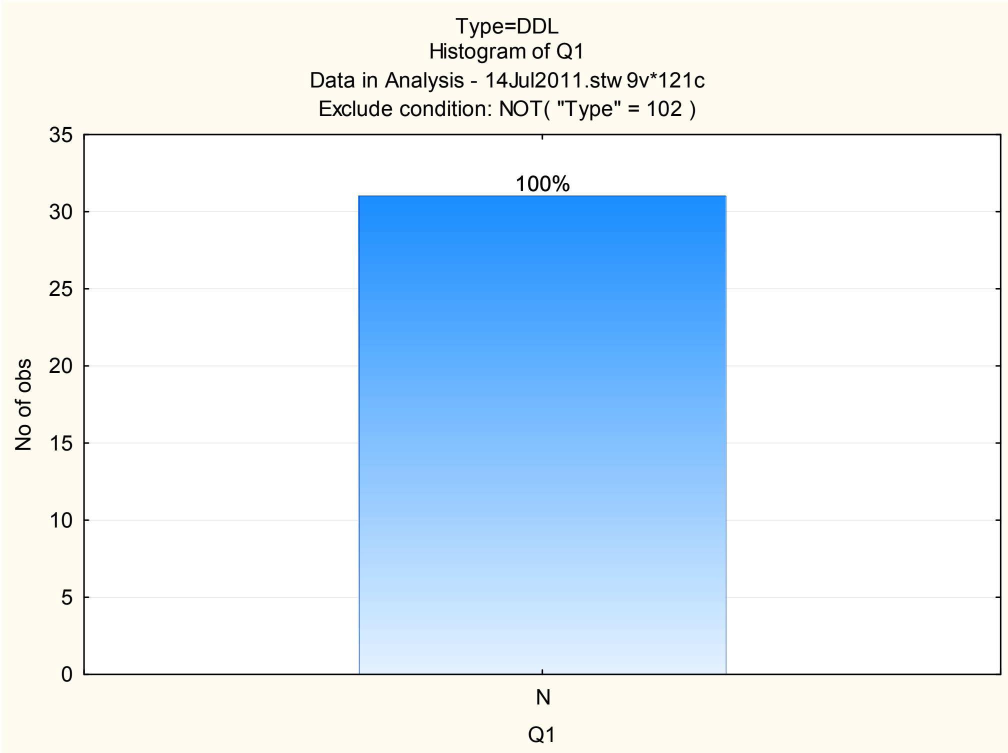
Type=DDL

Frequency table: Nationality (Spreadsheet in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative – Percent
Swiss	1	1	3.22581	3.2258
German	1	2	3.22581	6.4516
UK	1	3	3.22581	9.6774
Canadian	7	10	22.58065	32.2581
US	2	12	6.45161	38.7097
SA	3	15	9.67742	48.3871
Austrian	13	28	41.93548	90.3226
Missing	3	31	9.67742	100.0000

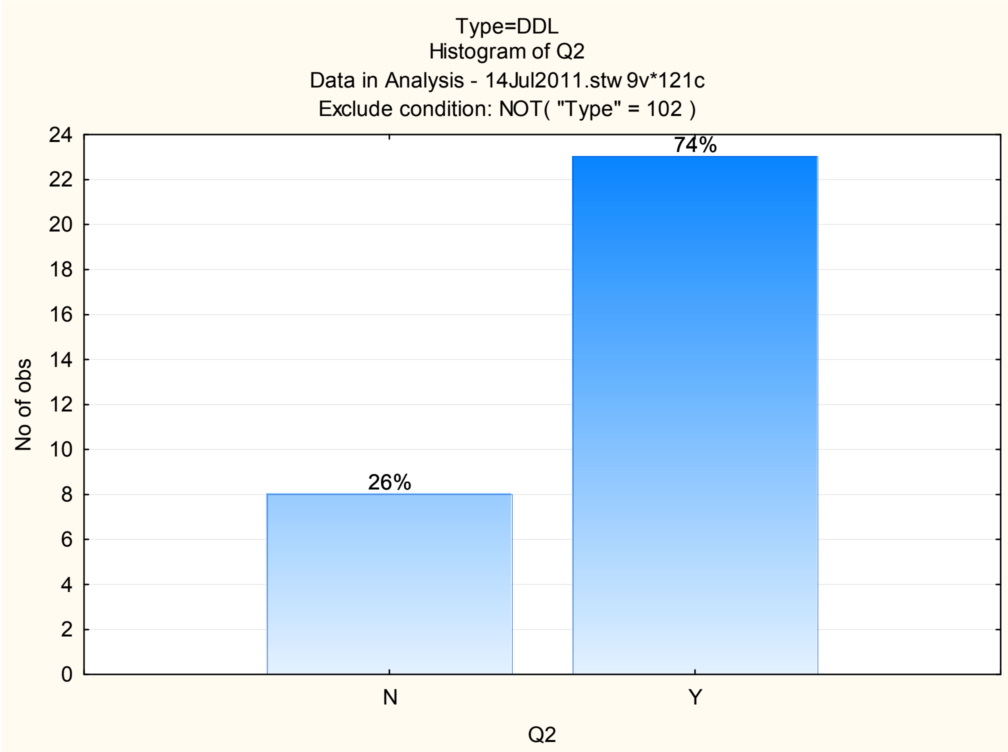


Type=DDL Frequency table: Trip (Spreadsheet in Analysis - 14Jul2011.stw)				
Category	**Count**	**Cumulative - Count**	**Percent**	**Cumulative – Percent**
Self Drive	14	14	45.16129	45.1613
Special	17	31	54.83871	100.0000
Missing	0	31	0.00000	100.0000

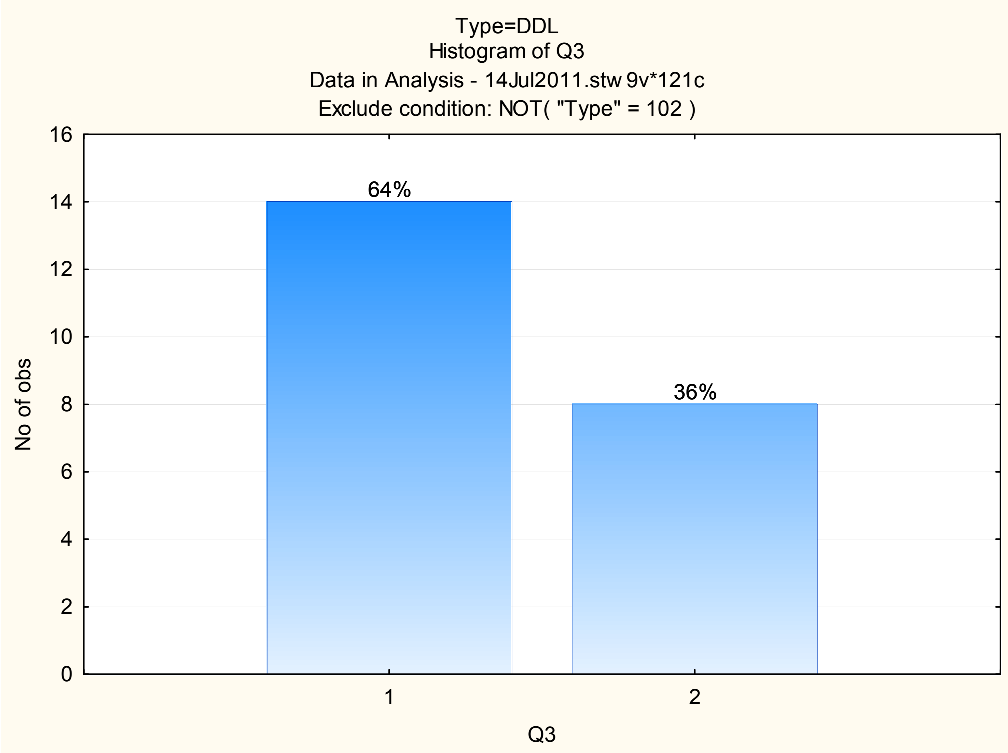


Type=DDL
Frequency table: Q1 (Spreadsheet in Analysis - 14Jul2011.stw)

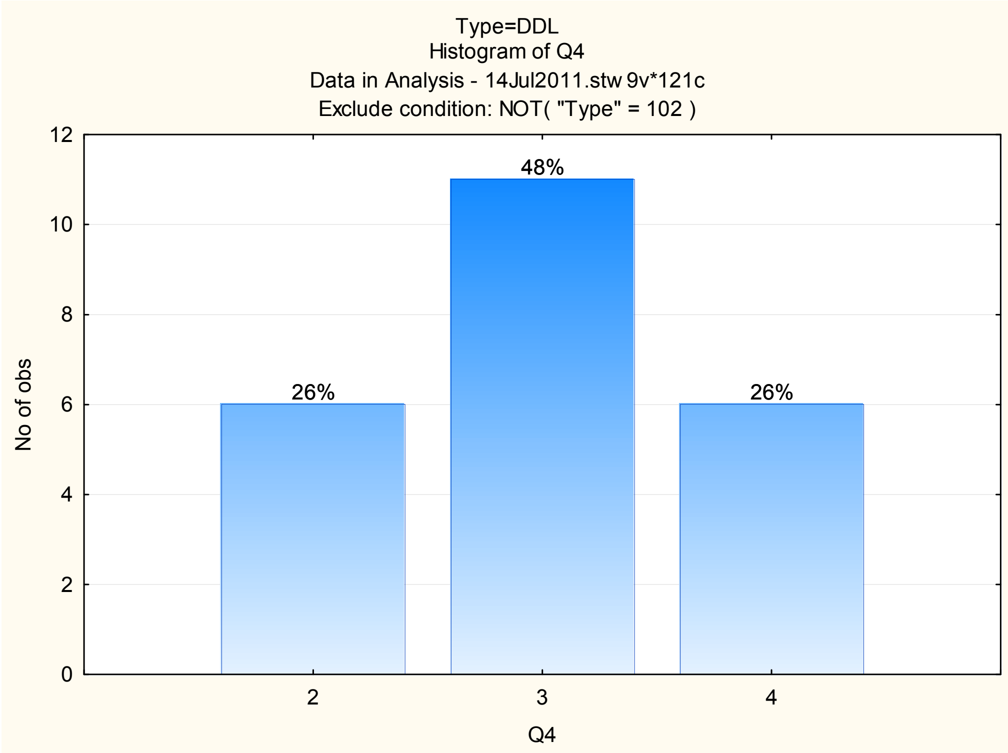
Category	Count	Cumulative - Count	Percent	Cumulative – Percent
N	31	31	100.0000	100.0000
Missing	0	31	0.0000	100.0000



Type=DDL Frequency table: Q2 (Spreadsheet in Analysis - 14Jul2011.stw)					
Category	**Count**	**Cumulative - Count**	**Percent**	**Cumulative – Percent**
N	8	8	25.80645	25.8065
Y	23	31	74.19355	100.0000
Missing	0	31	0.00000	100.0000

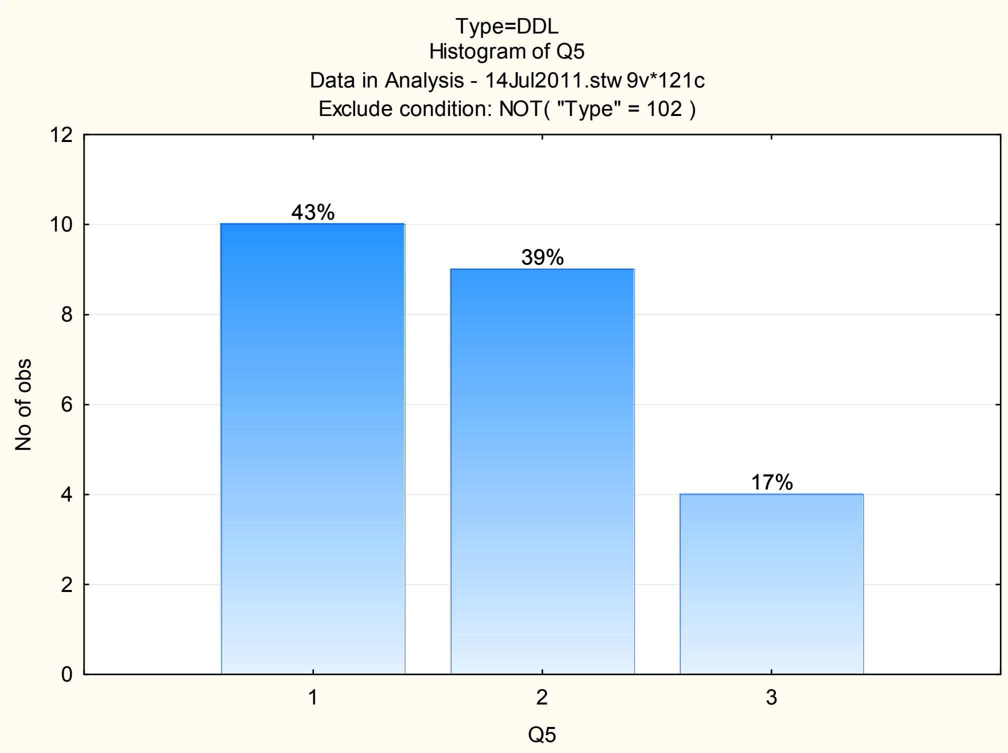


Type=DDL Frequency table: Q3 (Spreadsheet in Analysis - 14Jul2011.stw)					
Category	**Count**	**Cumulative - Count**	**Percent**	**Cumulative – Percent**
1	14	14	45.16129	45.1613
2	8	22	25.80645	70.9677
Missing	9	31	29.03226	100.0000



Type=DDL
Frequency table: Q4 (Spreadsheet in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative – Percent
2	6	6	19.35484	19.3548
3	11	17	35.48387	54.8387
4	6	23	19.35484	74.1935
Missing	8	31	25.80645	100.0000



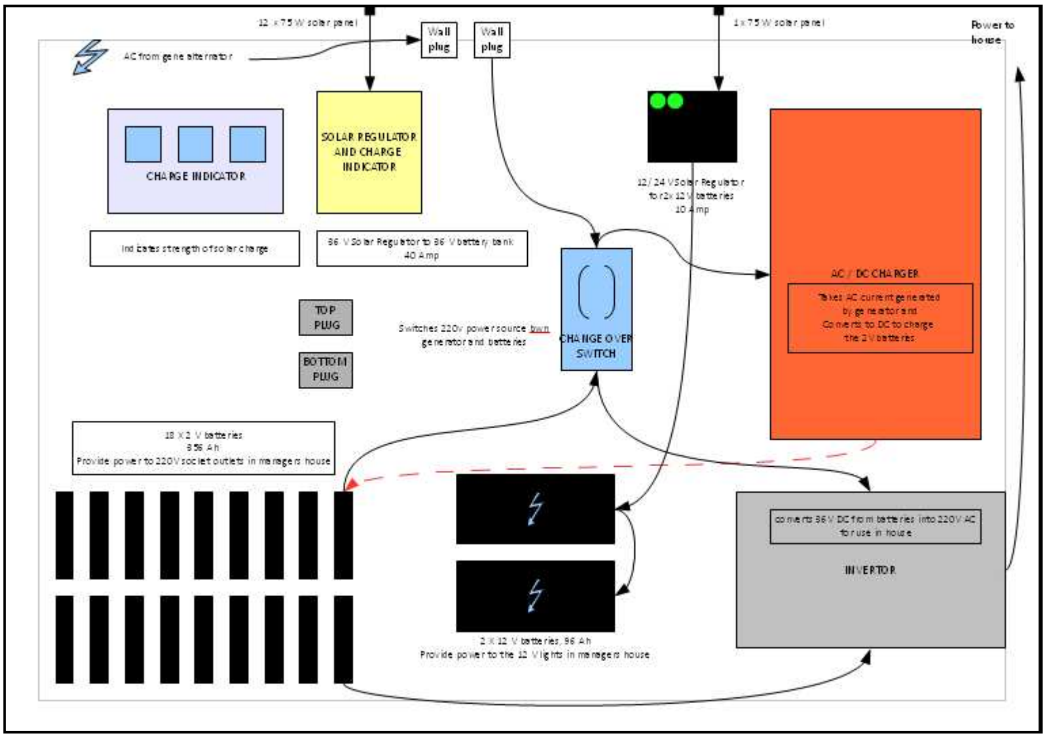
Type=DDL
Frequency table: Q5 (Spreadsheet in Analysis - 14Jul2011.stw)

Category	Count	Cumulative - Count	Percent	Cumulative – Percent
1	10	10	32.25806	32.2581
2	9	19	29.03226	61.2903
3	4	23	12.90323	74.1935
Missing	8	31	25.80645	100.0000

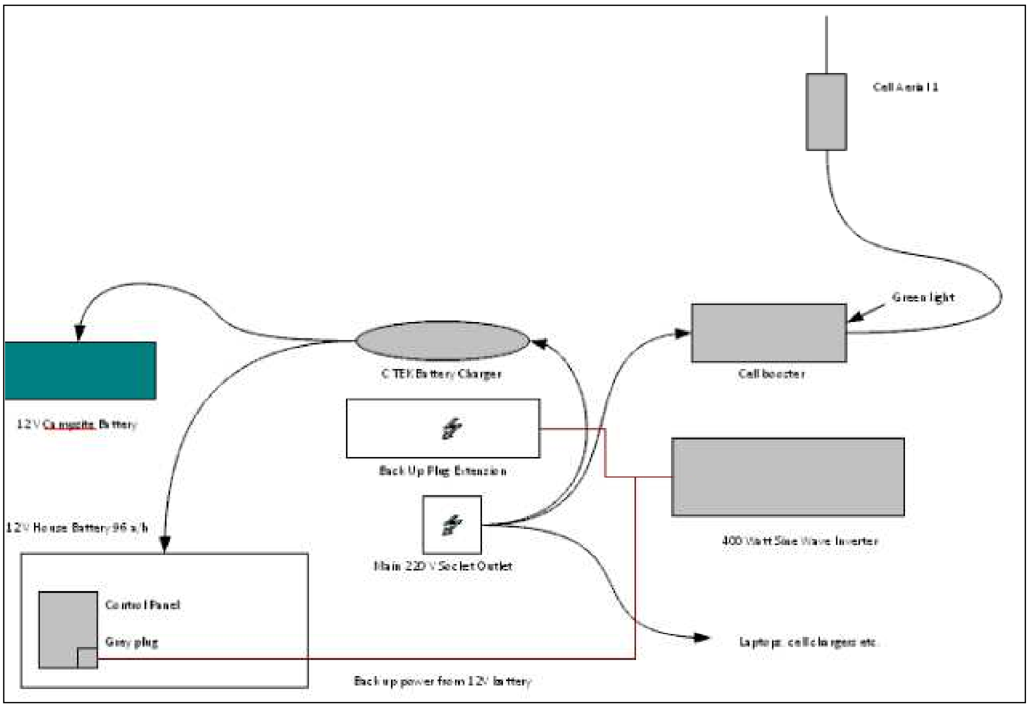
Type=DDL
T-tests; Grouping: Q2 (Spreadsheet in Analysis - 14Jul2011.stw)
Group 1: N
Group 2: Y

Variable	Mean - N	Mean - Y	t-value	df	p	Valid N - N	Valid N - Y	Std.Dev. - N	Std.Dev. - Y	F-ratio - Variances	p - Variances
Age	51.42857	56.44444	-0.850255	23	0.403948	7	18	17.54857	11.34083	2.394385	0.146491

7.4 Appendix D: Energy reticulation at manager's residence



7.5 Appendix E: Emergency power at manager's residence



7.6 Appendix F: Generator operating time for one year

Generator average operating time, hours for 16 months

1 May 2010 - 30 August 2011

Start	9787
End	11999.59
Total	2212.59
Days	486
Average p/d	4.55
365 days, one year	**1661.72**

7.7 Appendix G: Generator service intervals

Service interval	*10000*	*10100*	*10309*	*10500*	*10 776*
Date	01-May-10	09-Jun-10	24-Sep-10	12-Oct-10	22-Nov-10
Hours	9787	10100	10309	10539	10776
Notes	new hour meter new radiator, coolant new battery	new water pump tappet cover bolt belt replaced	injectors replaced		new radiator pipes inlet and outlet pipes coolant replaced
engine oil	√			√	
oil filter	√			√	
pre fuel filter	√			√	
final fuel filter	√			√	
injector nozzles replace		√			
thermostat replace		√			

Service interval	*11 000*	*11 500*	*11742*	*11952*	*12 000*
Date	04-Jan-11	15-May-11	10-Jul-11	19-Aug-11	08-Sep-11
Hours	10964	11500			11999.59
Notes	water pump replaced			new battery	
engine oil replace	√	√			√
oil filter replace	√	√			√
pre fuel filter replace	√	√			√
final fuel filter replace	√	NO	√		√
air filter replaced	√	√ (checked)			

7.8 Appendix H: Generator costing analysis for the period of one year

1 May 2010 - 30 Sept 2011		Changes	Volume	N$ per item	Items	Total
hour meter				136.00	1	136.00
radiator				4000.00	1	4000.00
thermostat				195.00	1	195.00
injector nozzles				1174.33	3	3522.99
water pumps				6699.00	2	13398.00
V belts				376.00	2	752.00
hose thermostat to water pump				64.00	1	64.00
radiator hose in and out				409.00	2	818.00
hose clamps				9.00	4	36.00
batteries				955.50	2	1911.00
radiator cap				195.00	2	390.00
tappet cover bolt				27.00	1	27.00
water pump gasket				15.00	1	15.00
oil filters				62.00	5	310.00
final fuel filters				225.00	5	1125.00
pre-fuel filters				232.00	5	1160.00
air filters				206.00	5	1030.00
oil	R 32.85 p/L	5 changes	6L each	32.85	30L	985.50
coolant	R 76.1 p/L	3 changes	14.5L each	76.10	43.5L	3310.35
				days	495	33185.84
				days	365, one year	**24470.37**

7.9 Appendix I: ULP and diesel costing for one year

ULP 95		'@ 6.7 kms p/L estimate for 4L V6 Hilux			Diesel fuel			
Days	N$	$ p/L *	litres	kms est	Days	N$	$ p/L *	Litres
01-Apr-10	6 665.79	7.91	842.70	5 646	01-Apr-10	4 980.56	7.84	635
01-May-10	3 738.81	7.74	483.05	3 236	01-May-10	3 680.00	8.04	458
01-Jun-10	2 850.40	7.74	368.27	2 467	01-Jun-10	1 676.05	7.91	212
01-Jul-10	2 431.43	7.64	318.25	2 132	01-Jul-10	3 650.33	7.91	461
01-Aug-10	2 195.15	7.64	287.32	1 925	01-Aug-10	2 171.02	7.81	278
01-Sep-10	600.06	7.54	79.58	533	01-Sep-10	6 574.09	7.81	842
01-Oct-10	4 138.95	7.54	548.93	3 678	01-Oct-10	4 664.12	7.76	601
01-Nov-10	3 021.65	7.64	395.50	2 650	01-Nov-10	5 967.87	7.72	773
01-Dec-10	2 577.00	7.64	337.30	2 260	01-Dec-10	2 479.29	7.72	321
01-Jan-11	1 507.60	7.99	188.69	1 264	01-Jan-11	3 923.05	8.21	478
01-Feb-11	3 427.86	8.34	411.01	2 754	01-Feb-11	4 057.40	8.56	474
01-Mar-11	7 441.02	8.74	851.38	5 704	01-Mar-11	977.75	9.16	107
01-Apr-11	2 778.70	9.14	304.02	2 037	01-Apr-11	10 795.48	9.71	1112
01-May-11	742.40	9.30	79.83	535	01-May-11	2 563.00	9.86	260
01-Jun-11	4 000.00	9.45	423.28	2 836	01-Jun-11	3 236.30	9.86	328
01-Jul-11	2 488.21	9.30	267.55	1 793	01-Jul-11	4 355.04	9.71	449
01-Aug-11	1 938.90	9.30	0.00	0	01-Aug-11	6 393.89	9.25	0
487	52 543.93		6 186.67	41 451	487	72 145.24	144.84	7788
						Average price	9.0525	
		L ULP for 365 days, one year	4636.83		N$ 365 days	54071.89	L diesel for 365 days, one year	5837

* Pump prices are given as being at Maltahöhe, this is not always the case though, especially with ULP, but for the purposes of this spreadsheet the difference is negligible.

7.10 Appendix J: Fuel use per motor

Unleaded: Toyota Hilux

Km 365 days	31066.73
ULP L 365 days	**4636.83**

Diesel: Toyota Land Cruiser

L/100 km	10.00*
km 365 days	19050.72
L 365 days	1905.07

Diesel: John Deere Generator

L/hr	2.50
hr/day	4.55
L/day	11.38
L/365 days	4154.30

Diesel: John Deere Gator

L/hr	2.50
hr/day	0.37
L/day	0.92
L/365 days	337

Total diesel**	Diff with Appendix I
6396.81	**559.53**

* Diesel fuel consumption figures were measured in situ. This figure may be noted as being modest, but represents driving at 20 - 30 kms p/h over generally flat terrain.
** This figure will not be 100% accurate due to varying fuel consumption depending on equipment condition, varying pump prices and initial and final diesel not being included, it is however accurate enough, over the period tested, for use in this context.

7.11 Appendix K: LPG use and prices

Date	Place	N$	Days	Price	kg
12-Jan-11	Agra Mariental	R 1 688.75	0	281.46	114
28-Feb-11	Marauns Maltahöhe	R 1 560.50	47	312.1	95
11-Apr-11	Agra Maltahöhe	R 1 070.78	42	267.5	76
06-Jun-11	Von Watsdorf Mariental	R 657.00	56	328.5	38
28-Jul-11	Agra Mariental		52		
		R 4 977.03	197		323

LPG prices at 23 September 2011		19kg
Agra, Maltahöhe:		R 375.37
Agra, Mariental:		R 354.20
Von Watsdorf, Mariental:		R 359.95
Marauns Garage, Maltahöhe:		R 375.00
	Average cost:	R 366.13
	Average price per kg:	R 19.27

7.12 Appendix L: LPG consumption and CO_2 production by LPG fridge and stove at DDL

LPG consumption by fridge / stove at DDL for price average @ 23 Sept 2011

Date installed	Days p/19kg		
		Ave days per 19kg	25.25
10-Feb-11	0	Ave kg/d	0.75
16-Mar-11	34	N$ 19.27 p/kg p/d	14.50
09-Apr-11	24	N$ p/30 days	435.01
30-Apr-11	21		
22-May-11	22		
Total days	101	% pd total LPG use	45.89%

kg/day	**1.64**
N$ pd	25.26
CO_2 / kg LPG	2.95
Kg CO_2 p/197 days	952.85
Kg CO_2 p/365 days/ 1 year	**1765.43**

7.13 Appendix M: CO_2 calculations

Current

	Litres ULP	Litres diesel	Km/yr	kg CO2/L	kg CO2/km	kg CO2/yr
John Deere Gator		337.44		2.65		894.21
John Deere generator		4154.30		2.65		11008.89
Toyota Hilux	4636.83		31066.73		0.31	9630.69
Toyota Land Cruiser		1905.07	19050.72		0.36	6858.26
LPG						1765.43
	4636.83	6396.81	50117.46			30157.05

7.14 Appendix N: Balance sheet extractions

	Groceries	Fuel	Wages
Sept	R 6 041.45	R 7 244.16	R 3 200.00
Aug	R 5 692.57	R 8 332.79	R 3 300.00
July	R 6 041.15	R 6 843.25	R 2 000.00
June	R 9 641.65	R 7 266.30	R 4 850.00
May	R 6 950.20	R 3 305.40	R 4 700.00
	R 34 367.02	R 32 991.90	R 18 050.00
Per month	R 6 873.40	R 6 598.38	R 3 610.00