THE MACRO ECONOMY AND IRRIGATION AGRICULTURE IN THE NORTHERN CAPE PROVINCE OF SOUTH AFRICA

by

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Declaration:

I declare that the thesis hereby submitted by me for the PhD degree in Agricultural Economics at the University of the Free State is my own independent work and has not previously been submitted by me at another university/faculty.

Pieter Taljaard

Date

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This thesis is dedicated to my farther:

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My greatest mentor and example in live

THE MACRO ECONOMY AND IRRIGATION AGRICULTURE IN THE NORTHERN CAPE PROVINCE OF SOUTH AFRICA

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ABSTRACT

The overall objective of this study was to develop a model capable of quantifying the economy-wide impacts of market risk and other exogenous factors, with specific reference to efficient irrigation water use along the banks of the middle and lower Orange River in the Northern Cape Province (NCP). The study is based on the second of two parts of a larger Water Research Commission (WRC) funded project, titled: "*Market risk, water management and the multiplier effects of irrigation agriculture with reference to the NCP*".

One of the sub-objectives was to simulate the effects of selected market change(s), i.e. a change in the world price of fruit, on the provincial economy as well as to quantify the economy-wide impact of selected regional shocks and structural changes. A second sub-objective includes recommendations on institutional responses that will increase effective water management for regions where irrigation agriculture makes a major contribution to the economy such as the NCP. The ability to quantify and/or simulate the economic-wide effects of different exogenous shocks or risk factors influencing agriculture and specifically irrigation agriculture therefore contributes to the group of already existing decision support systems available to role-players and decision makers in South Africa.

In order to reach the first specific sub-objective, two sets of economic linkages between the micro and macro economic models were applied, i.e. one bottom-up or micro-to-macro and the other a top-down or macro-to-micro. The top-down linkage, utilizes the simulated results from a static

Computable General Equilibrium (CGE) model, calibrated to a Social Accounting Martix (SAM), as inputs into a Dynamic Linear Programming (DLP) model on farm and irrigation regional level. A 20% reduction in the world price of fruits was used as simulation in the CGE model, with the main linkage between the macro and micro economic models being the changes in the local prices of fruits. Some of the key results from the micro analysis include amongst others the level of structural adjustments and other influencing factors, including the impact on farm and regional level profitability for example.

With the bottom-up linkages, simulated results (i.e. the changes in the objective function values) from the regional DLP model was multiplied by three sets of economic multipliers (production, value added and labour) in order to quantify the economy-wide impacts thereof. Despite numerous shortcomings of economic multipliers, this analysis was performed to quantify in broad terms the direct, indirect and induced economy-wide impacts resulting from amongst others a 20% decrease in the local price of table grapes under various water trade and crop deviation allowances specified in the DLP model.

As hypothesised, the simulated results explained above proved that significant economy-wide impacts can result from market risks or other exogenous factors influencing local irrigation agriculture, especially in a region where irrigation agriculture plays such an important role as in the NCP. It is believed that the current South African water law is comprehensive and well-written compared to international standards and benchmarks. The implementation thereof, in many aspects however remains a challenge. Recommendations on required institutional responses to improve the effectiveness of irrigation water utilization were made to reach the second specific sub-objective.

The main conclusion from this study is that South Africa is relatively under-developed in the management of water supply and demand. In this regard, innovative technological development combined with cutting edge research in this field, is the only way in which effective water use will ultimately advance and thereby optimise the net benefit of society as a whole. It therefore calls for an integrated water resource management approach, with commitment from all role players involved. Government should provide an enabling environment, within which all levels from the private sector and communities can participate in the form of Public-Private-Partnerships (PPP) to enhance prosperous economic growth and development.

DIE MAKRO-EKONOMIE EN BESPROEIINGSLANDBOU IN DIE NOORDKAAP PROVINSIE VAN SUIDAFRIKA

deur

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UITTREKSEL

Die oorhoofse doelwit van die studie was die ontwikkelling van ‘n model wat in staat is om die ekonomiese-wye impakte van mark risiko en ander eksogene veranderlikes te kwantifiseer met spesifieke verwysing na effektiewe besproeiings water gebruik langs die oewers van die middel an laer Oranjerivier in die Noordkaap Provinsie (NKP). Die studie is gebasseer op die tweede gedeelte van ‘n breër Water Navorsings Kommisie (WNK) befondste studie, getiteld: “*Mark risiko, water bestuur en die vermenigvuldiger effekte van besproeiingslandbou met verwysing na die NKP”*.

Een van die sub-doelwitte was om die effek van geselkteerde mark verandering(s) te simuleer, d.i. ‘n verandering in die internasional (wêreldprys) van vrugte op die provinsiale ekonomie so-wel ekonomie-wye impak van geselekteerde regionale skokke en struktuur veranderings. ‘n Tweede sub-doelwit sluit aanbevelings in aangaande institusionele reaksies vir die meer effektiewe water bestuur vir streke waat besproeiingslandbou so ‘n groot rol bydrae to die eknomie lewer soos in die NKP. Die moontlikheid om die ekonomie-wye impak te kwantifiseer of van eksogene veranderlikes te simuleer maak ‘n bydrae aan die reeds bestaande besluitnemings ondersteunings sisteme beskikbaar vir rolspelers en besluitnemers in landbou en meer spesifiek besproeiingslandbou in Suid Afrika.

Om die eerste sub-doelwit te bereik is daar van twee stelle ekonomiese koppellings gebruik gemaak; eerstens ‘n mikro-na-makro of “bottom-up” en die ander ‘n makro-na-mikro of top-down. Die makro-na-mikro kopelling gebruik die sumilasie resultate van ‘n Berekende Algemene

Ewewigs model wat gekalibreer is tot ‘n Sosiale Rekenings Matriksas insette to ’n Dinamiesie Lineëre Programmerings model op plaas en besproeiingsstreeks valk. Die resultate van ‘n 20% daling in die wêreldprys van vrugte is gebruik as simulasie kopelling tussen die makro en mikro ekonomiese modelle met die veranderings in die plaaslike vrugte pryse as hoof veranderlikes. Van die kern mikro-ekonomiese resultate sluit onder andere die vlak van struktuur veranderings asook ander faktore, insluitend die impak of plaas en streeks winsgewendheid byvoorbeeld.

In die geval van die mikro-na-makro koppellings, is die gesimuleerde resultate (d.i. die veranderings in die doelwitfunksie waardes) van die regional DLP model vermenigvuldig met drie stelle ekonomiee vermenigvuldigers (produksie, waardetoevoeging en arbeids) om die ekonomie-wye impak daarvan te bereken. Ten spyte van verskye tekortkomminge met ekonomiese ermenigvuldigers,is die analisese gedoen om ‘n breë terme die direkte, indirekte en geinduseerde impakte van onder andere ‘n 20% daling in die plaaslike prys van tafel druiwe onder verskeie water handel en gewas beperkings soos gespesifiseer in die DLP model.

Soos die hipotese gestel, het die gesimuleerde effekte soos hierbo verduidelik geweldige ekonomie-wye impakte as gevolg van die mark risikos asook ander eksogene faktore wat die plaaslike besproeiingslandbou, spesifiek in streke soos die Noord-kaap waar besproeiing so kardinale deel vorm. Die huidige water wetgewing in Suid Afrika is omvattend en weldeurdag in vergelyking met internasionale standaarde. Die implementering hiervan bly steed ‘n groot uitdaging in verskeie aspekte. Voorstelle aangaande institusionele reaksies die effektiwiteit van die aanvending van besproeiingswater te verbeter word gemaak om die tweede sub-doelwit te bereik.

Die hoof gewolgtrekking van die studie is dat Suid Afrika relatief onder-ontwikkel is in die bestuur van die vraag na en aanbod van water. In die verband is innoverende tegnologiese ontwikkellings, gekombineerd met “snykant” navorsing in die veld die enigste manier waarop effektiewe water gebruik bereik kan word. Daar word dus ‘n beroep gedoen vir ‘n geintegreerde water hulbron bestuurs benadering, met die inkoop van alle belanghebbendes. Die regering van die dag moet dus ‘n “enabling omgewing daar stel, waarbinne alle vlakke van die privaat sektor asook gemeenskappe kan deelneem in die vorm van Staats-privaat-ooreenkomste om volhoubare ekonomiese groei en ontwikkelling te verseker.

TABLE OF CONTENTS

CONTENTS **PAGE**

Acknowledgements **... *i***
Abstract **.. *iii***
Uittreksel **... *v***
Table of Contents **.. *vii***
List of Tables **.. *xii***
List of Figures **... *xv***
List of Abbreviations **.. *xvi***
Keywords **... *xvii***

CHAPTER 1 *INTRODUCTION*

1.1 INTRODUCTION AND BACKGROUND 1
1.2 PROBLEM STATEMENT AND NEED FOR THE STUDY 2
1.3 OBJECTIVES 4
1.4 MOTIVATION 5
1.5 METHODOLOGY AND DATA USED 6
1.6 OUTLINE OF THE STUDY 7

CHAPTER 2 *LITERATURE REVIEW*

2.1 INTRODUCTION 9
2.2 MACRO ECONOMIC ACCOUNTING AND MODELLING METHODOLOGIES 10
2.2.1 NATIONAL ACCOUNTING 11
2.2.2 INPUT/OUTPUT (I/O) TABLES 11
2.2.3 SOCIAL ACCOUNTING MATRIX (SAM) 13
2.2.4 IMPACT ANALYSIS 20
2.2.5 MULTIPLIER ANALYSIS 21
2.2.6 BACKWARD AND FORWARD LINKAGES 23
2.2.7 COMPUTABLE GENERAL EQUILIBRIUM (CGE) MODEL 24
2.2.8 DIFFERENCE BETWEEN MACRO-ECONOMETRIC AND CGE MODELLING APPROACHES 27
2.2.9 ADVANTAGES OF SAM-CGE FRAMEWORK 27
2.2.10 ECONOMETRIC CRITIQUE OF CGE MODELLING 29
2.2.11 SCHOOLS OF THOUGHT 29

2.2.11.1 ORTHODOX SCHOOL ... 29
2.2.11.2 ECLECTIC SCHOOL ... 30
2.2.11.3 ECUMENICAL SCHOOL ... 30
2.3 EMPIRICAL MACRO-ECONOMIC IMPACT STUDIES AND MODELS ... 30
2.3.1 INPUT/OUTPUT (I/O) MODELS AND VARIANTS THEREOF ... 30
2.3.2 SOCIAL ACCOUNTING MATRIX (SAM) BASED MODELS ... 37
2.3.3 APPLIED COMPUTABLE GENERAL EQUILIBRIUM (CGE) MODELS ... 39
2.3.3.1 STATIC CGE MODELS ... 39
2.3.3.2 DYNAMIC CGE MODELS ... 49
2.3.4 OTHER IMPACT MODELS ... 52
2.4 RISK AND THE AGRICULTURAL ECONOMY OF THE NCP ... 53
2.4.1 REGIONAL ECONOMIC MODELLING FRAMEWORK APPLIED ... 53
2.4.2 RESULTS OF THE REGIONAL ECONOMIC SCENARIOS ... 54
2.5 GOVERNANCE AND WATER MANAGEMENT ... 56
2.5.1 EFFECTIVE WATER GOVERNANCE ... 57
2.5.1.1 SUSTAINABLE GOVERNANCE ... 57
2.5.1.2 NEW VS. TRADITIONAL GOVERNANCE ... 58
2.5.1.3 GOVERNANCE IN DEVELOPING AND DEVELOPED COUNTRIES ... 58
2.5.2 THE NEED FOR AN INTEGRATED MANAGEMENT APPROACH ... 58
2.5.2.1 INTEGRATED WATER RESOURCE MANAGEMENT DEFINED AND EXPLAINED ... 60
2.5.2.2 THE ROLE OF INFORMATION ... 61
2.5.2.3 THE ROLE OF INSTITUTIONS ... 61
2.5.2.4 THE ROLE OF THE PRIVATE SECTOR ... 62
2.5.3 WATER AS STRATEGIC RESOURCE – THE CONCEPT OF VIRTUAL WATER (VW) ... 63
2.5.4 TECHNOLOGICAL INNOVATION ... 64
2.5.5 DECISION SUPPORT SYSTEMS ... 65
2.6 CONCLUSION ... 65

CHAPTER 3 ***OVERVIEW OF THE NORTHERN CAPE ECONOMY, NATIONAL WATER RESOURCES AND IRRIGATION WATER REGULATIONS***

3.1 INTRODUCTION ... 66
3.2 TOPOGRAHY, REGIONS AND POPULATION DEMOGRAPHICS IN THE NCP ... 68
3.3 DEMOGRAPHICS IN THE AGRICULTURAL SECTOR ... 71

3.4 AGRICULTURE AND HOUSEHOLD INCOME IN THE NORTHERN CAPE 72
3.5 ECONOMIC SECTORS 73
3.5.1 PRIMARY INDUSTRIES 74
3.5.1.1 AGRICULTURE, FORESTRY AND FISHING 75
3.5.1.2 MINING AND QUARRYING 85
3.5.2 SECONDARY INDUSTRIES 86
3.5.2.1 MANUFACTURING AND PROCESSING 86
3.5.2.2 UTILITIES: ELECTRICITY/GAS AND WATER 87
3.5.2.3 CONSTRUCTION... 87
3.5.3 TERTIARY INDUSTRIES 87
3.5.3.1 WHOLESALE AND RETAIL TRADE; HOTELS AND RESTAURANTS.......................... 88
3.5.3.2 TRANSPORT AND COMMUNICATION 89
3.5.3.3 FINANCE, REAL ESTATE AND BUSINESS SERVICES 89
3.5.3.4 COMMUNITY, SOCIAL AND OTHER PERSONAL SERVICES.................................. 89
3.6 IRRIGATION WATER AS A SCARCE ECONOMIC COMMODITY IN SOUTH AFRICA 89
3.7 CURRENT WATER REGULATION IN SOUTH AFRICA.. 92
3.7.1 THE WATER POLICY 93
3.7.2 THE WATER ACT 94
3.7.3 THE NATIONAL WATER RESOURCE STRATEGY.. 95
3.8 SUMMARY 96

CHAPTER 4 *DEVELOPMENT OF THE ECONOMIC-WIDE MODELLING FRAMEWORK*

4.1 INTRODUCTION 97
4.2 THE PROVIDE SAM 98
4.2.1 ADJUSTMENTS MADE TO THE ORIGINAL SAM.. 98
4.3 ECONOMIC MULTIPLIERS FOR THE NCP.. 99
4.3.1 SAM LEONTIEF MULTIPLIERS 101
4.4 THE CGE MODEL FOR THE NCP 103
4.4.1 ACTIVITIES, PRODUCTION AND FACTOR MARKETS 105
4.4.2 INSTITUTIONS 106
4.4.3. COMMODITY MARKETS 106
4.4.4 MACROECONOMIC BALANCES/CLOSURE RULES 107
4.4.4.1 THE EXTERNAL CLOSURE 108

4.4.4.2 THE SAVINGS-INVESTMENT CLOSURE ... 108
4.4.4.3 THE GOVERNMENT CLOSURE ... 109
4.4.4.4 FACTOR MARKET CLOSURES ... 109
4.4.4.5 CHOICE OF CLOSURE COMBINATIONS ... 110
4.4.4 MODEL CODE ... 110
4.5 LINKAGES BETWEEN MACRO AND MICRO MODELS ... 111
4.5.1 MICRO-MACRO LINKAGES (BOTTOM UP) ... 111
4.5.2 MACRO-MICRO LINKAGES (TOP DOWN) ... 113
4.6 CONCLUSION ... 113

CHAPTER 5 *SIMULATING THE EFFECT OF MARKET CHANGES – A CGE ANALYSIS*

5.1 INTRODUCTION ... 115
5.2 SIMULATING A DECREASE IN WORLD EXPORT PRICE OF FRUIT (PWEDECR) BY MEANS OF THE CGE MODEL ... 116
5.2.1 SECTORAL IMPACTS (EFFECT ON ACTIVITIES) ... 118
5.2.1.1 INTERMEDIATE INPUT COSTS ... 121
5.2.1.2 ACTIVITY PRICE AND QUANTITY EFFECTS ... 122
5.2.1.3 ACTIVITY INCOME EFFECTS ... 124
5.2.2 COMMODITY EFFECTS ... 125
5.2.3 FACTOR IMPACTS ... 127
5.2.3.1 EMPLOYMENT ... 128
5.2.3.2 FACTOR RENTAL/WAGE RATES ... 130
5.2.3.3 RETURN TO LAND ... 131
5.2.4 SOCIO (HOUSEHOLD) AND WELFARE IMPACTS ... 132
5.2.5 GOVERNMENT EFFECTS ... 135
5.3 CONCLUSION ... 135

CHAPTER 6 *ECONOMIC MULTIPLIERS FOR THE NORTHERN CAPE PROVINCE*

6.1 INTRODUCTION ... 137

6.2 RESULTS OF THE MULTIPLIER ANALYSIS 137
6.2.1 LABOUR MULTIPLIERS 138
6.2.2 PRODUCTION MULTIPLIERS 140
6.2.3 VALUE-ADDED MULTIPLIERS 142
6.3 BOTTOM-UP LINKAGES – APPLYING THE ECONOMIC MULTIPLIERS TO THE REGIONAL MODEL SIMULATIONS 143
6.3.1 REGIONAL ECONOMIC MODELLING FRAMEWORK AND SCENARIOS 144
6.3.2 BOTTOM-UP EFFECTS OF MICRO-ECONOMIC SCENARIOS 145
6.3.2.1 LABOUR IMPACTS 145
6.3.2.2 PRODUCTION IMPACTS 147
6.3.2.3 VALUE-ADDED IMPACTS 148
6.4 CONCLUSIONS 149

CHAPTER 7 *SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS*

7.1 INTRODUCTION 150
7.2 SUMMARY OF FINDINGS 150
7.2.1 ECONOMY-WIDE METHODOLOGY 151
7.2.2 RESULTS OF THE ECONOMY-WIDE MODELS 152
7.3 CONCLUSIONS 155
7.4 RECOMMENDATIONS 159
7.4.1 INSTITUTIONAL RESPONSE REQUIRED 160
7.4.1.1 FARM LEVEL RESPONSE 163
7.4.1.2 INDUSTRY OR ORGANIZED AGRICULTURE RESPONSE 163
7.4.1.3 NATIONAL AND PROVINCIAL GOVERNMENT RESPONSE 165
7.4.3 RECOMMENDATIONS ON FUTURE RESEARCH 169

REFERENCES 171

APPENDIX 4A: AGGREGATE MACRO PROVIDE SAM 185
APPENDIX 4B: ACCOUNT DESCRIPTIONS USED IN THE ADJUSTED PROVIDE SAM 186
APPENDIX 4C: GAMS CODE FOR CGE MODEL: 191
APPENDIX 4D: GAMS CODE FOR CGE SIMULATION 196

LIST OF FIGURES

FIGURE 1.1: THE WIDER AGRICULTURAL SYSTEM 3
FIGURE 2.1: SCHEMATIC PRESENTATION OF ECONOMIC CIRCULAR FLOW....................14
FIGURE 2.2: THE FLEXIBLE AGGREGATION PROCEDURE....................27
FIGURE 2.3: MAJOR VIRTUAL WATER FLOWS AS A CONSEQUENSE OF FOOD TRADE BETWEEN 1995 AND 1999. 64
FIGURE 3.1: MAP OF THE REPUBLIC OF SOUTH AFRICA....................66
FIGURE 3.2: THE DISTRICT MUNICIPALITIES OF THE NCP....................67
FIGURE 3.3: MAP OF THE NORTHERN CAPE PROVINCE 68
FIGURE 3.4: REGIONS OF THE NORTHERN CAPE....................69
FIGURE 3.5: POPULATION DENSITY BY PROVINCE (PERSONS/KM2) 70
FIGURE 3.6: AGE DISTRIBUTION OF THE NC AND SOUTH AFRICAN POPULATION....................71
FIGURE 3.7: PROVINCIAL GDP CONTRIBUTIONS IN 2003 72
FIGURE 3.8: GROSS GEOGRAPHICAL PRODUCT BY SECTOR (% OF TOTAL IN 1999) 74
FIGURE 3.9: PROVINCIAL CONTRIBUTION TO PRIMARY SECTOR GGP (1999) 75
FIGURE 3.10: PROVINCIAL CONTRIBUTION TOWARDS THE NATIONAL TOTAL 75
FIGURE 3.11: ESTIMATED CATTLE, SHEEP AND GOAT NUMBERS (QUARTERLY AVERAGE, NOVEMBER 2001 - NOVEMBER 2003)....................76
FIGURE 3.12: FAMING UNITS AND GROSS FARM INCOME 78
FIGURE 3.13: EMPLOYEE REMUNERATION 79
FIGURE 3.14: GROSS FARM INCOME BY AGRICULTURAL DIVISION AND REGION IN THE NCP 79
FIGURE 3.15: SHARE OF ARABLE CROPS IN THE NCP 80
FIGURE 3.16: SHARE OF FIELD AND FODDER CROPS IN THE NCP....................81
FIGURE 3.17: REGIONAL ARABLE CROPS PRODUCTION IN THE NCP 81
FIGURE 3.18: SHARES OF SELECTED HORTICULTURAL CROPS IN THE NCP 82
FIGURE 3.19: REGIONAL PRODUCTION OF SELECTED VEGETABLES 82
FIGURE 3.20: REGIONAL PRODUCTION OF SELECTED OTHER HORTICULTURAL CROPS IN THE NCP 83
FIGURE 3.21: NATIONAL AREA UNDER CULTIVATION PER DECIDUOUS FRUIT TYPE 84
FIGURE 3.22: REGIONAL GRAPE INCEPTIONS FOR THE 2005/06 SEASON 85
FIGURE 3.23: PROVINCIAL CONTRIBUTION TOWARDS THE NATIONAL TOTAL 86
FIGURE 3.24: PROVINCIAL CONTRIBUTION TOWARDS THE NATIONAL TOTAL 88
FIGURE 3.25: LOCATION OF WATER MANAGEMENT AREAS AND INTER-WATER MANAGEMENT AREA TRANSFERS 90
FIGURE 3.26: COMPARISON OF THE MEAN ANNUAL RUNOFF (MAR), POPULATION AND ECONOMIC ACTIVITY (GDP) PER WATER MANAGEMENT AREA 91

Figure 3.1: Map of the Republic of South Africa....66
Figure 3.2: The district municipalities of the NCP....67
Figure 3.3: Map of the Northern Cape Province....68
Figure 3.4: Regions of the Northern Cape....69
Figure 3.5: Population density by province (persons/km2)....70
Figure 3.6: Age distribution of the NC and South African population....71
Figure 3.7: Provincial GDP contributions in 2003....72
Figure 3.8: Gross geographical product by sector (% of total in 1999)....74
Figure 3.9: Provincial contribution to primary sector GGP (1999)....75
Figure 3.10: Provincial contribution towards the national total....75
Figure 3.11: Estimated cattle, sheep and goat numbers (quarterly average, November 2001 - November 2003)....76
Figure 3.12: Faming units and gross farm income....78
Figure 3.13: Employee remuneration....79
Figure 3.14: Gross Farm Income by agricultural division and region in the NCP....79
Figure 3.15: Share of arable crops in the NCP....80
Figure 3.16: Share of field and fodder crops in the NCP....80
Figure 3.17: Regional arable crops production in the NCP....81
Figure 3.18: Shares of selected horticultural crops in the NCP....82
Figure 3.19: Regional production of selected vegetables....82
Figure 3.20: Regional production of selected other horticultural crops in the NCP....83
Figure 3.21: National area under cultivation per deciduous fruit type....84
Figure 3.22: Regional Grape inceptions for the 2005/06 season....85
Figure 3.23: Provincial contribution towards the national total....86
Figure 3.24: Provincial contribution towards the national total....88
Figure 3.25: Location of water management areas and inter-water management area transfers....90
Figure 3.26: Comparison of the mean annual runoff (MAR), population and economic activity (GDP) per water management area....91
Figure 4.1: Schematic presentation of the production technology in a CGE model105
Figure 4.2: Schematic presentation of the flows of marketed commodities....107
Figure 4.3: Micro-macro links....112
Figure 5.1: Northern Cape Provincial Map....117
Figure 5.2: Change in regional agricultural GDP at factor costs (GDPTAB2P)...119
Figure 5.3: Price changes of activity output (PAXP)....120
Figure 5.4: Aggregate activity intermediate input price (PINTAXP)....122

FIGURE 5.5: ACTIVITY PRODUCER PRICE (PATAB) 123
FIGURE 5.6: DOMESTIC AGRICULTURAL ACTIVITY LEVELS (QAXP) 124
FIGURE 5.7: PRICE CHANGES OF ARABLE CROPS AT DIFFERENT LEVELS (IMPORT PRICE - PMXP, COMPOSITE COMMODITY PRICE - PQXP, DOMESTIC SUPPLY PRICE - PDSXP) 126
FIGURE 5.8: QUANTITY EFFECTS OF ARABLE CROPS (DOMESTIC SALES - QDXP, COMPOSITE MARKETED QUANTITY - QQXP, IMPORT - QMXP, EXPORT - QEXP)....................127
FIGURE 5.9: EMPLOYMENT OF SEMI- AND UNSKILLED LABOUR CATEGORIES (QFSXP) 129
FIGURE 5.10: EMPLOYMENT DEMAND PER LABOUR (WITH FULL EMPLOYMENT ASSUMED) CATEGORY FROM NORTHERN CAPE AGRICULTURAL ACTIVITIES (QFXP)............129
FIGURE 5.11: EMPLOYMENT DEMAND PER LABOUR CATEGORY (QFXP) 130
FIGURE 5.12: RETURNS TO NORTHERN CAPE LAND UNDER FULL AND UNEMPLOYMENT SCENARIO (WFDISTXP)..132
FIGURE 5.13: HOUSEHOLD POPULATION DISTRIBUTION IN THE NCP 133
FIGURE 5.14: HOUSEHOLD CONSUMPTION EXPENDITURE (EHXP) FOR FULL EMPLOYMENT AND UNEMPLOYMENT SCENARIOS 134
FIGURE 5.15: EQUIVALENT VARIATION (EV) FOR THE NCP HHS..134
TABLE 5.1: NCP AGRICULTURAL REGIONS..117
TABLE 5.2: QUANTITY OF FRUIT OUTPUT (QXACXP), SHARES OF TOTAL OUTPUT AND SIMULATED RESULTS FOR THE NCP AGRICULTURAL ACTIVITIES 121
TABLE 5.3: ACTIVITY VALUE ADDED EFFECTS (R VALUES FOR 2000) 125
TABLE 5.4: SEMISKILLED AND UNSKILLED LABOUR CATEGORIES IN THE MODEL.....................128
TABLE 5.5: DESCRIPTION OF THE NCP HOUSEHOLD CATEGORIES.......................................133
TABLE 5.6: GOVERNMENT FINANCE..135

LIST OF TABLES

TABLE 2.1: TYPICAL OUTLINE OF A SAM....17
TABLE 2.2: MAIN USES AND MISUSES OF CGE MODELS....26
TABLE 2.3: SECTORAL COMPOSITION OF FLOW-ON EFFECTS....33
TABLE 3.1: AVERAGE HOUSEHOLD INCOMES IN THE NORTHERN CAPE....73
TABLE 3.2: NCP AGRICULTURAL REGIONS....77
TABLE 3.3: NUMBER OF PAID EMPLOYEES PER AGRICULTURAL OCCUPATION IN THE NCP....78
TABLE 3.4: WATER REQUIREMENTS FOR THE YEAR 2000 (MILLION M^3/A)....92
TABLE 6.1: LABOUR MULTIPLIERS....139
TABLE 6.2: PRODUCTION MULTIPLIERS....141
TABLE 6.3: VALUE-ADDED MULTIPLIERS....143
TABLE 6.4: SELECTED MICRO-ECONOMIC SCENARIOS AND CORRESPONDING MACRO-ECONOMIC LABOUR IMPACTS....146
TABLE 6.5: PRODUCTION EFFECTS OF SELECTED MICRO-ECONOMIC SCENARIOS....147
TABLE 6.6: VALUE-ADDED EFFECTS OF SELECTED MICRO-ECONOMIC SCENARIOS....148

LIST OF ABBREVIATIONS AND ACRONYMS USED:

ARMPF	Agricultural Risk Management Policy Framework
AsgiSA	Accelerated and Shared Growth Initiative for South Africa
BMR	Bureau of Market Research
DI	Disposable Income
DBSA	Development Bank of Southern Africa
DDS	Decision Support Systems
DTI	Department of Trade and Industry
HPHC	Home production for home consumption
GGP	Gross Geographical Product
GM	Genetically Modified
GOS	Gross Operating Surplus
GTAP	Global Trade Analysis Project
I/O	Input-Output
IIO	Interregional Input Output
IES	Income and Expenditure Survey
IWRM	Integrated Water Resource Management
ME	Macro-econometric
NAMC	National Agricultural Marketing Council
NDoA	National Department of Agriculture
NC	Northern Cape
NCP	Northern Cape Province
NWA	National Water Act
NWP	National Water Policy
PPP or P3	Public Private Partnership
SATI	South African Table Grape Industry
SAM	Social Accounting Matrix
SSA	Sub-Saharan Africa
StatsSA	Statistics South Africa
TG	Table Grape
VW	Virtual Water
WMA	Water Management Area
WEFA	Wharton Econometric Forecasting Association
WRC	Water Research Commission
WUA	Water Users' Association

KEYWORDS:

Computable General Equilibrium model, economic multipliers, economy-wide, effective water use, virtual water, policy framework, institutional response, Social Accounting Matrix, risk, simulations, scenarios, decision support systems.

CHAPTER 1 *INTRODUCTION*

Table of Contents:

1.1 INTRODUCTION AND BACKGROUND....1
1.2 PROBLEM STATEMENT AND NEED FOR THE STUDY....2
1.3 OBJECTIVES....4
1.4 MOTIVATION....5
1.5 METHODOLOGY AND DATA USED....6
1.6 OUTLINE OF THE STUDY....7

List of Figures:

FIGURE 1.1: THE WIDER AGRICULTURAL SYSTEM ____ 3

CHAPTER 1

INTRODUCTION

"I do not mean that others should be eased and you burdened, but that as a matter of equality your abundance at the present time should supply their want, so that their abundance may supply your want, that there may be equality." ***The Bible, 2 Corinthians 8: 13 and 14***

1.1 INTRODUCTION AND BACKGROUND

The liberalised free market agricultural environment in the Republic of South Africa is just over one decade old. Over the past decade, major changes in the agricultural business environment affected decision makers and others directly or indirectly involved in agriculture in different ways and in varying degrees. With the introduction of free markets, resulting fluctuations in prices brought about a whole new dimension of risk that agriculturalists were not always prepared to manage.

As in China (specifically Northern China) and other countries across Asia, the Middle East, North Africa and the northern part of Sub-Saharan Africa, irrigated agriculture in the **Northern Cape Province (NCP)** remains a key sector both in terms of its share in GDP and the proportion of the poor dependent on the sector.

Grapes, including table grapes (mainly produced for the export market) and dry grapes or raisins, are the most important fruit commodity produced in the Northern Cape Province (NCP), earning more than 95% of the total fruit value share within the province. More specifically, in the case of the table grape industry, the last three to five seasons have proven extremely challenging for producers. Given the relatively high input costs of table grapes in the NCP, and declining world market prices, table grape producers in the NCP experienced a substantial decline in their profitability. The decline in world prices, especially in the early part of the table grape season, can mainly be ascribed to increased competition from Latin American countries like Brazil, Argentina and Chile. In addition to this, the constant rising input costs coupled with the fluctuations of the Rand against the major currencies (US Dollar and Euro) exacerbate the risk within which these grape producers operate. For some producers, the ever-changing (more demanding) supply chain, as well as changes in consumer preferences (seeded grapes compared to seedless grapes), can be considered the last straw breaking the camel's back, leading to liquidations of various table grape producers in the Lower Orange River area.

Inventing and implementing social mechanisms for the allocation of irrigation water for more productive uses remains a challenge in both developed and developing countries. Diao, Roe and Doukkali (2004) list three basic explanations for this difficulty. Firstly, part of the difficulty lies in the problem of establishing the property rights of water. Secondly, the relatively high cost of dams and canals associated with surface water raises the issue of who should bear the cost and whether marginal cost pricing for water should be abandoned. Thirdly, the negative externalities that ground water extraction imposes on the extraction of water by others can prove problematic. Dia, Roe and Doukkali*.* (2004) further also describe the heterogeneous nature of water availability within a country/region, which further complicates the formulation of a uniform water policy.

South Africa's National Water Policy (National Department of Water Affairs and Forestry, 2004), adopted by cabinet in 1997, states that: "The objective of managing the quantity, quality and reliability of the nation's water resources is to achieve optimum, long-term, environmentally sustainable, social and economic benefits for society from their use." As stated by the National Department of Water Affairs and Forestry (2004) three fundamental objectives for managing South Africa's resources are emphasised, including:

- Achieving equitable access to water,
- Achieving sustainable use of water by making progressive adjustments to water use with the objective of striking a balance between water availability and legitimate water requirements, and
- Achieving efficient and effective water use for optimum social and economic benefit.

This study is based on the second part of a Water Research Commission (WRC) project, with the title: "Market risk, water management and the multiplier effects of irrigation agriculture with reference to the Northern Cape Province of South Africa". The results from the first part, i.e. the farm and regional level modelling, are used as inputs in this study to make recommendations on the institutional responses required to improve the effective use of irrigation water.

1.2 PROBLEM STATEMENT AND NEED FOR THE STUDY

Roberts (1991) points out that any casual observer of agricultural production in post-war years would have noticed that the farm sector does not operate in isolation but has direct interfaces with 'upstream' and 'downstream' industries in the food chain. In other words, changes in the operation of the agricultural sector will have repercussions or 'knock-on' effects on other production sectors in the economy.

Agricultural production is therefore one of many interconnecting facets between the farm sector and the wider economy. In supporting this argument, three links between these sectors are listed by Josling (1985), including:

- The importance of farm household consumption and savings in non-agricultural markets,
- The hiring of factors of production (labour), which is often influenced by the integration between rural and urban markets, and
- The valuation of farm assets and debts, which reflects not only on agriculture's prosperity, but also on non-farm valuations.

Errington (1991) describes what he refers to as the Wider Agricultural System, normally characterised as the outcome of agricultural development. From Figure 1.1 the links from agriculture to both "upstream" (the suppliers of inputs) and "downstream" (those who handle and process farm outputs) are clear. A third component of this Wider Agricultural System is made up of the control mechanisms through which society seeks to modify the actions of the individuals within the resulting system. Important to note is that some organisations are involved both upstream and downstream, while various government agencies have a place in all three the components mentioned.

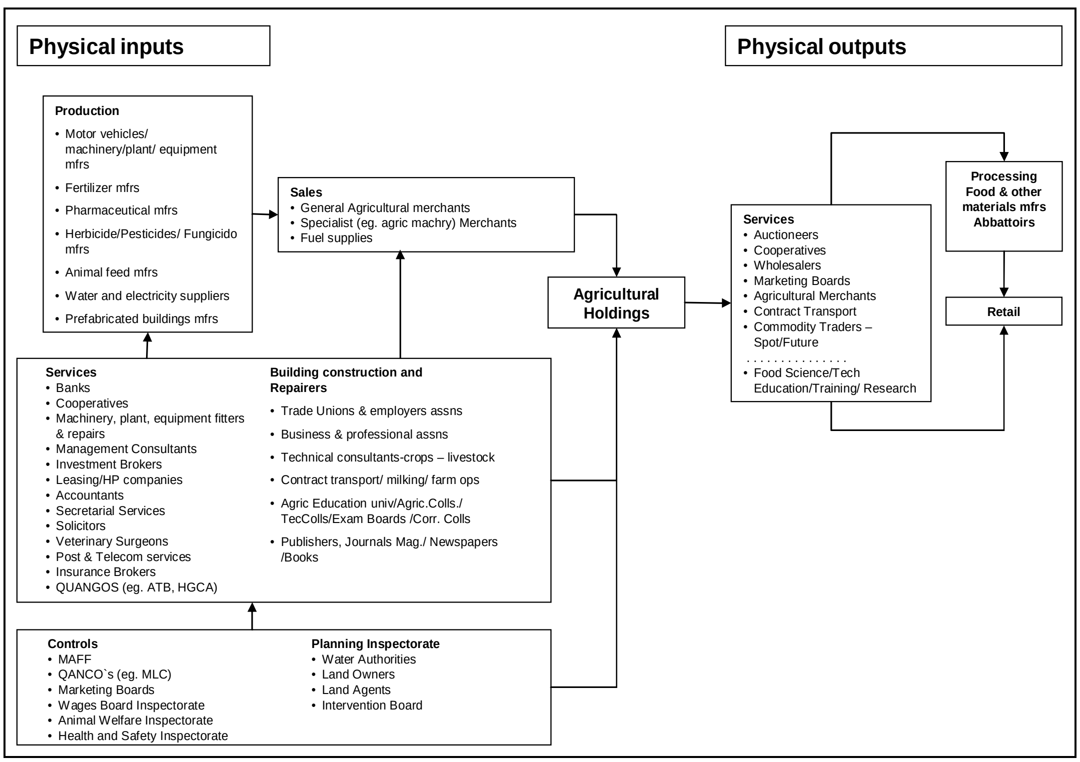


Figure 1.1: The wider agricultural system
Source: Adopted from Errington (1991) as in Midmore (1991)

Figure 1.1 illustrates the large degree of interdependence between agriculture and other sectors of the economy. Clearly, any changes in agriculture are likely to have repercussions on the other sectors. Input/Output (I/O) tables or Social Accounting Matrices (SAMs) provide means of exploring some of these linkages. Errington (1991) states that the quantification of these linkages can assist the policymaker in answering some important questions, such as:

- How important is agriculture to the rest of the economy in the region/country?
- What are the likely repercussions of changes in agriculture on other sectors of the economy?

In terms of water availability, like many other countries, South Africa is water scarce with an average rainfall of 500 mm per year, which is well below the world average of 860 mm per annum. Furthermore it is estimated that the national water demand will exceed supply by the year 2025 (Letsoala, Blignaut, De Wet, De Wit, Hess, Tol and Van Heerden, 2007). It is therefore of the utmost importance that the available water resources are utilised in the best possible way, which requires the quantification of the impact of water use. Hellegers and Perry (2004) explain that economics provides tools to analyse the implications of changes or shocks effecting water use. The Second World Water Forum (The Hague, March 2000) stressed that decisions on water allocation among competing uses require a better analysis of the value of water (SWWF, 2000 as in Hellegers and Perry, 2004), whereas the International Conference on Water and the Environment (Dublin, January 1992) emphasised that failure to recognise the value of water has led to environmentally damaging uses of the resource (ICWE, 1992 as in Hellegers and Perry, 2004). Given the important role that irrigation agriculture plays in the NCP, it is of the utmost importance that the role-players (producers, water authorities, policy-makers, etc.) involved in irrigation agriculture have the required decision-support instruments at their immediate disposal whenever planning is done or decisions affecting the sector are made. From the discussion above, it is clear that a macro-economic model capable of tracing shocks throughout all economic sectors is a very important decision-support tool required in the management of a sector like irrigation agriculture in the NCP.

According to Hassan (1998), for many years the water resources in South Africa have been over utilized, inefficiently allocated and over-polluted as a result of poor policy regimes. Sector/industry-specific analysis may often result in the omission of important impacts, and it is therefore important when analysing a specific part of the economy that this is done in an economy-wide framework. As a result, economy-wide analyses ensure that all feedback effects of the interconnected sectors in the economy are captured. Another advantage of an economy-wide analysis is that it enables consistency checks in such a way that reality can be tested by means of adding-up, for example.

1.3 OBJECTIVES

The overall objective of the study is to quantify the effect of external shocks in irrigation agriculture on the macro-economy of the Northern Cape. The macro-economy in the context of this study refers to production activities, commodities, factors of production (i.e. labour, capital and land), socio- economics and welfare effects (including employment and income) as well as on the government (i.e. savings, income and spending). In order to reach this overall objective, the more specific sub-objectives include:

i. To determine from the literature on macro-economic modelling the most appropriate methodological framework.
ii. To identify and quantify the contributions of relevant products and economic sectors in the Northern Cape economy.
iii. To develop an appropriate economy-wide modelling framework for NCP.
iv. To simulate the effects of selected market change(s) on the provincial economy as well as to quantify the economy-wide impact of selected regional shocks and structural changes.
v. To recommend the institutional responses that should be made to mitigate the effect of such external shocks and thereby increase the effectiveness of water management for regions where irrigation agriculture makes a major contribution to the economy. In addition also, to make further recommendations on institutional responses that will reduce risks and improve the financial viability of the individual farmers and irrigation schemes.

This study hereby strives to add to the group of already existing Decision Support Systems (DSS) available to the irrigation agricultural fraternity specifically, an economic-wide (macro-economic) modelling framework capable of quantifying the impacts of external shocks, like exogenous risk factors, trade policies, etc.

1.4 MOTIVATION

Coon and Randal (2005) explain that measuring the economic contribution that a specific firm, crop or industry makes to the provincial/national economy provides valuable macro-economic indicators. The importance of these indicators is reflected in the large number of entities that have commissioned studies to determine these values. McDonald and Punt (2005) explain that the agricultural sector and the rural populations who derive their livelihoods from the land are considered to have unique characteristics that warrant careful consideration in policy analysis.

According to Roe, Dinar, Tsur and Diao (2005) agriculture consumes the "lion's share" – between 75 and 90% – of the annual renewable fresh water on earth, which is sufficient reason for policymakers to focus their efforts on improved performance of water use in irrigated agriculture, especially when water scarcity becomes a crucial policy issue. Roe, Dinar, Tsur and Diao. (2005) go on to state that most economic analyses of policy interventions in the irrigation sector address questions at the farm or regional level, with one common weakness of this approach being the inability to track the feedback links between the policies. Concurring with many other authors listed by Roe *et al.* (2005), they also found that policy interventions at the farm and regional (micro) level could lead to desirable results while narrow considerations may also lead to sub-optimal outcome from a social point of view. Roe *et al.* (2005) therefore argue that the linkages among micro and macro policy interventions are far more important and allow policy-makers to better assess the outcome of intervention.

The need for more comprehensive information on the effect of different policy alternatives by policy-makers has led to an increasing number of economic impact studies being conducted (Kirsten and Van Zyl, 1990a). Kirsten and Van Zyl (1990a) state that in South Africa, a need arose to determine the scope of the economic impact of irrigation infrastructure development in order to motivate the capital investments. They go on to explain that relatively little concrete evidence exists on the economic contribution that irrigation agriculture in South Africa makes to overall economic development. With many users competing for the limited water resource base in South Africa, water not only sustains the functions of the natural ecosystems and provides for basic human need, but also supports important productive economic activities that create income, wealth and jobs for the people of the country (Hassan, 2003).

Given the importance of inter-sectoral linkages in any economy, shocks or changes in a particular sector in the NCP may have far-reaching effects on the economy of the Northern Cape, as well as the rest of South Africa. It is therefore important to consider the economy-wide impacts of expected adjustments in the agricultural sector, and more specifically the irrigation agriculture sector in the NCP due to its relative importance and therefore reliance on water.

1.5 METHODOLOGY AND DATA USED

In order to quantify the economic impact of market risk affecting irrigated crops (particularly fruit) grown in the NCP on the provincial economy, a macro-economic database is required. An adjusted national SAM with disaggregated detail for the agricultural activities, households and production factors in the NCP, compiled by PROVIDE (2005b), were used as macro-economic database for this study.

Kirsten and Van Zyl (1990a) investigated five fundamentally different methodologies for economic impact studies, including an economic basis study, I/O models, econometric models, mathematical programming models, and the comparison of regions methodology.

Hess (2005) explains that Computable General Equilibrium (CGE) models link economic theory to observed accounting data from regions and countries in order to measure the changes that occur in the data after certain policy variables within the model have been shocked. CGE models therefore allow for experimental settings with hypothetical policy scenarios. Mukherjee (1996) explains that a CGE model is the economist's version of a laboratory in which it is possible to conduct experiments. Firstly, the model translates the textbook description of an economy, with utility-maximising consumers and profit-maximising producers, into a mathematical format. It then allows the researcher to shock the system in order to evaluate the economy-wide effects of the shock. Gohin (2003) explains that CGE models are often employed by virtue of the attractive feature of being able to capture all distortions in an economy. Cogneau and Robilliard (2000) elucidate that the nature of the links between economic growth, poverty and income distribution is a question that is central to the study of economic development. Globally, a number of approaches have been taken to analyse these links. Among these, CGE models are preferred due to their ability to produce disaggregated results at the micro-economic level, within a consistent macro-economic framework (Cogneau and Robilliard, 2000).

Two macro-economic modelling frameworks are used in this study. Firstly, a static CGE model, based on the standard IFPRI CGE model, is calibrated to a SAM in order to simulate possible shocks, firstly on the national economy and on the NCP economy. Selected variables resulting from these simulations are then linked (used as input variables in a top-down approach) to the regional (irrigation) level model, see Louw, Van Schalkwyk, Grové and Taljaard (2007) in order to quantify the impact and mimic the structural changes that can be expected at farm level. Secondly, economic multipliers calculated from the SAM are used to quantify the macro economic impacts (in a bottom-up approach) resulting from selected regional economic scenarios or simulations provided by Louw *et al.* (2007).

1.6 OUTLINE OF THE STUDY

This study is primarily concerned with the macro-economic impacts of selected market risks or other possible changes (economic shocks) affecting the irrigation agricultural in the NCP. In order to sufficiently address this, a literature review on economy-wide modelling methodologies is provided in the next chapter. It furthermore also presents relevant literature on examples of effective governance and water management frameworks.

In Chapter 3 the economic sectors of the NCP are described and analysed according to the Standard Industry Classification (SIC) system. The SAM database used for the macro-economic models is also used to give a descriptive analysis of the households and agricultural activities in the NCP. In addition to this, a description of irrigation water as scarce resource as well as an overview of the current water regulations in South Africa, are dealt with. The data and methodology used, as well as the calibration of the macro-economic (CGE) model, are discussed in Chapter 4.

The results of the fruit price scenario analysed by means of the CGE model are reported in Chapter 5, whereas Chapter 6 deals with the economic multipliers calculated and the estimated macro-economic impacts resulting from a regional Dynamic Linear Programming (DLP) model.
Chapter 7 firstly provides a summary of findings and secondly, draws some conclusions based on the results. In addition, suggestions on institutional responses required to improve the effectiveness of irrigation water, as well as to reduce risk and improve the financial viability of

irrigation farmers and regions are provided in the third section, with some final recommendations on future research at the end to conclude the study.

CHAPTER 2

LITERATURE REVIEW

Table of contents:

2.1 INTRODUCTION 9
2.2 MACRO ECONOMIC ACCOUNTING AND MODELLING METHODOLOGIES 10
2.2.1 National accounting 11
2.2.2 Input/Output (I/O) tables 11
2.2.3 Social Accounting Matrix (SAM) 13
2.2.4 Impact analysis 20
2.2.5 Multiplier analysis 21
2.2.6 Backward and forward linkages 23
2.2.7 Computable General Equilibrium (CGE) model 24
2.2.8 Difference between macro-econometric and CGE modelling approaches 27
2.2.9 Advantages of SAM-CGE framework 27
2.2.10 Econometric critique of CGE modelling 29
2.2.11 Schools of thought 29
2.2.11.1 Orthodox school 29
2.2.11.2 Eclectic school 30
2.2.11.3 Ecumenical school 30
2.3 EMPIRICAL MACRO-ECONOMIC IMPACT STUDIES AND MODELS 30
2.3.1 Input/Output (I/O) models and variants thereof 30
2.3.2 Social Accounting Matrix (SAM) based models 37
2.3.3 Applied Computable General Equilibrium (CGE) models 39
2.3.3.1 Static CGE models 39
2.3.3.2 Dynamic CGE models 49
2.3.4 Other impact models 52
2.4 RISK AND THE AGRICULTURAL ECONOMY OF THE NCP 53
2.4.1 Regional economic modelling framework applied 53
2.4.2 Results of the regional economic scenarios 54
2.5 GOVERNANCE AND WATER MANAGEMENT 56
2.5.1 Effective water governance 57
2.5.1.1 Sustainable governance 57
2.5.1.2 New vs. traditional governance 58
2.5.1.3 Governance in developing and developed countries 58
2.5.2 The need for an integrated management approach 58
2.5.2.1 Integrated Water Resource Management defined and explained 60
2.5.2.2 The role of Information 61
2.5.2.3 The role of Institutions 61
2.5.2.4 The role of the Private sector 62
2.5.3 Water as strategic resource – the concept of Virtual Water (VW) 63

2.5.4 Technological innovation 64
2.5.5 Decision Support Systems 65
2.6 CONCLUSION 65

List of figures:

FIGURE 2.1: SCHEMATIC PRESENTATION OF ECONOMIC CIRCULAR FLOW _____ 14
FIGURE 2.2: THE FLEXIBLE AGGREGATION PROCEDURE _____ 27
FIGURE 2.3: MAJOR VIRTUAL WATER FLOWS AS A CONSEQUENSE OF FOOD TRADE BETWEEN 1995 AND 1999. _____ 64

List of tables:

TABLE 2.1: TYPICAL OUTLINE OF A SAM _____ 17
TABLE 2.2: MAIN USES AND MISUSES OF CGE MODELS _____ 26
TABLE 2.3: SECTORAL COMPOSITION OF FLOW-ON EFFECTS _____ 33

CHAPTER 2

LITERATURE REVIEW

"*There is only one fundamental law in economics: for every income there is a corresponding outlay or expenditure" (Pyatt, 1988)*

2.1 INTRODUCTION

The most important divide in the subject matter of economic study is that between micro and macro economics. Micro economics on the one hand is the study of individual markets, industries and consumer decisions, whereas macro economics on the other hand tackles overall questions concerning inflation, unemployment and growth. However, the theory of micro-economic foundations provides a link, at least in neoclassical terms, that is the most appealing practical tool for describing the way in which individual sectors of the economy relate to one another overall (Midmore, 1991).

Midmore (1991) further recommends that it is especially appropriate to consider agriculture from this perspective, since in contrast to most other activities, a large proportion of its revenue is accounted for by purchases of materials and services from other industries, while a high proportion of its output is sold to processing industries before passing to final consumers. As the largest economic activity in rural areas, it is almost unique in its dependence on the large-scale use of land as a productive resource.

Economic models, and more specifically CGE models, help to understand all the highly complex interactions in an economy and thus to be in a position to make better-informed decisions. According to Robinson and Löfgren (2005) since the late 1970s, real CGE models have provided the dominant framework for economy-wide, multi-sectoral models. This is mainly because these models provide an attractive and natural framework for macro poverty analysis, given their ability to link the macro and micro levels and account for how incomes and consumptions of different household groups are affected by economic shocks and policy changes.

In the next section, a brief review of the literature on economy-wide modelling methodologies is given, followed by economy-wide impact studies in the third section. In the fourth section a description of a regional DLP model and scenario results for irrigation agriculture in the NCP as developed by Louw *et al.* (2007) are dealt with. Section five deals with literature and examples of effective governance and water management structures which is followed by conclusions in the final section.

2.2 MACRO ECONOMIC ACCOUNTING AND MODELLING METHODOLOGIES

Marco-economic modelling and more specifically CGE is a highly complicated field of study due to the diverse nature of the subject field. Bayar (2005) discusses these complexities noting that a successful modeller should posses the following five basic proficiencies: Firstly, the modeller must be an excellent economist in order to understand the complexities of the real world. Secondly, he/she needs to be a good mathematician and thirdly must also be an outstanding statistician. In the fourth place, such a modeller also needs to understand mathematical programming, and finally he/she should value archiving like any fine librarian.

A macro-economic model basically consists of a set of mathematical equations that embodies the history of theoretical and empirical knowledge *vis-à-vis* the economy. There are essentially three key elements in a macro-economic model, i.e. i) identities, ii) behavioural equations, and iii) exogenous inputs into the model. When compiling a macro-economic model, and more specifically also a policy model, the model should have the following desirable features (Devarajan and Robinson, 2002b):

- **Relevance** – It should be relevant in the sense that policy variables should be linked to outcomes and therefore address the concerns of the policymakers or other role players involved. It should furthermore also be relevant concerning the winners and losers of a particular shock or change.
- **Transparency** – It should be proven in the model that the modeller is unbiased in his efforts and that he attempted to consider all impacts.
- **Timelines** – This means that if required, the model should be dynamic and employ the most recent data due to the fact that some economies change quite often.
- **Validation** and estimation techniques used should be the relevant techniques and the modeller should further ensure that the results obtained are reasonable, i.e. does the model explain anything we observe today or in the recent past?
- **Diversity of approaches** indicates that different situations (shocks) require the application of alternative techniques.

In addition to the criteria mentioned above, economic models should be reviewed and updated by experts on a continuous basis to ensure the usefulness thereof.

The data requirements of these macro-economic models are quite comprehensive. In the next section, the methodology of capturing macro-economic data is discussed. Firstly a brief introduction to national accounting is provided, followed by two different but interrelated methods by means of which national accounts can be recorded, i.e. input/output (I/O) tables and Social

Accounting Matrices (SAMs). In addition to this, various methods, models or modelling techniques (that can be applied to analyse macro-economic data), including impact analysis, multiplier analysis, backward and forward linkages, and Computable General Equilibrium (CGE) models, are also introduced. The section is then concluded by a discussion firstly on the differences between CGE and macro econometrics and secondly on the advantages of an SAM-CGE framework for macro-economic analysis.

2.2.1 National accounting

A System of National Accounts (SNA) is a comprehensive framework in which the basic statistical data on transactions among micro-producing units, for example establishments, may be presented with minimum manipulation of statistical data. Statistical data can realistically be presented in a basic supply-and-use framework of an SNA in three ways: Firstly, any producing unit may engage in more than one activity producing more than one type of product. Secondly, goods and services as well as outputs are as far as possible valued at the prices at which they first entered the market, i.e. basic prices or at equivalent market prices; they are only valued at costs when no equivalent market prices are available. Thirdly, goods and services like intermediate or final products are valued at the prices that the ultimate consumers/users have to pay for them (United Nations, 1999).

2.2.2 Input/Output (I/O) tables

Input/Output (I/O) analysis as a theoretical framework and an applied economic tool in a market economy was developed by Wassily Leontief with the construction of the first input/output tables for the United States for the years 1919 and 1929, published in 1936 (United Nations, 1999). It was not until Leontief introduced an assumption of fixed-coefficient linear production functions, relating inputs used by an industry along each column to its output flow, that I/O analysis became an economic tool. The development of the I/O methodology, and the later integration of the I/O framework into the system of national accounts in 1968, earned both Leontief and Stone Nobel prizes in 1973 and 1984 respectively for their respective contributions.

I/O tables present a database with which to analyse the local economy. In its simplest form it is possible to use the I/O table to describe the local economy. The assumption on which the fundamentals of an I/O table are based can be traced back to Francois Quesnay's *Tableau Economique*, which is a descriptive device showing sales and purchase relations among producers and consumers in an economy. These techniques basically assume that I/O relationships can be transformed into technical relationships, with each column an I/O coefficient table representing a technique of production.

The major focus of the study in the application of the I/O technique has been on the management of the aggregate economy, as well as the forecasting, planning, development and analysis of technical change (Midmore, 1991). The ability to quantify inter-sectoral relationships, i.e. the effect of a change in one sector on all other sectors of an economy, is precisely what is lacking in conventional partial equilibrium approaches.

Kebede and Ngandu (1999) explain that an I/O model is a system of equations that characterise the state of the economy, which is demand driven, and assumes that the supply is perfectly elastic. They also point out that typically, an I/O model is based on the following assumptions: linear production structure with fixed input requirements, constant returns to scale, and inputs available at fixed relative prices, as well as sufficient quantities to meet the demand, i.e. an increase in the demand for an input does not lead to a rise in the input price.

An I/O table therefore basically focuses on the interrelationships between industries in an economy with respect to the production and uses of their products, including exports, and the products imported from abroad. From another angle, in tabular format, an I/O table represents the economy by listing each industry as a consuming sector across the top and down the side as a supplying sector.

Van Seventer (1999) describes three basic applications of regional I/O tables. Firstly, he explains that regional I/O tables can be used as a framework to study the relative regional characteristics. Of interest is often the sectoral composition compared to other sectors or to the nation as a whole. Secondly, regional I/O tables are handy as a policy analysis tool, for example, to determine the impact of macro-economic policies on the regional economy. Thirdly, regional I/O tables can also be used to investigate the impact on the local economy of new investment projects and new or changed production activities, or the effect of external market shocks.

The basic strength of I/O analysis, as mentioned, is that it helps to explain inter-sectoral economic relationships within an economy, whether regional or national. In contrast, Midmore (1991) notes that the weaknesses of I/O analysis are firstly that it relies on linear, average relationships. Secondly, it precludes substitution between inputs in productive processes but assumes that inputs are perfectly elastic in supply, and thirdly, the infrequent publication and long period of gestation of most national I/O tables is also seen as a serious drawback.

The two basic components of an I/O table are the “make matrix” and the “use matrix”. The make matrix shows the gross output of industries classified by the goods (commodities) produced, whereas the use matrix shows the purchases of domestic and imported goods.

2.2.3 Social Accounting Matrix (SAM)

Similar in sense to an I/O table, the Social Accounting Matrix (SAM) is a comprehensive, economy-wide data framework, typically representing the economy of a nation or region. More technically, the SAM is a square matrix in which each account is represented by a row and a column. Following the research of Nobel prize-winner Richard Stone, the SAM is a comprehensive, disaggregated, consistent and complete data system that captures the interdependencies that exist within a socio-economic system (Mabugu, 2005). According to PROVIDE (2003) the versatility of SAMs has made them the databases of preference for economic modelling.

Each cell shows the payment from the account of its column to the account of its row (Löfgren, 2002). In particular, Sen (1996) describes any element of the SAM as a receipt (incoming) for the account specified by the row in which the item is located, and it is an expenditure (outgoing) for the account identified by its column location. An item in row i, column j is therefore an outgoing payment by account j, which is received by account i. The most important feature of the SAM is that it provides a consistent and convenient approach to organising economic data for a country and it can provide a basis for descriptive analysis and economic modelling in order to answer various economic-related questions, including policy questions (Pleskovic and Trevino, 1985).

Round (1981) defines the SAM as a single-entry accounting system whereby each macro-economic account is represented by a column for expenditures or payments and a row for incomes or receipts. It is represented in the form of a square matrix, with row and columns, which brings together data on the production and income generation of different institutional groups and classes on the one hand, and data on expenditure of these incomes by these groups and classes on the other. Robinson, Yunnez-Naude, Hinojosa-Ojeda, Lewis and Devarajan (1999) explain that the SAM is the synthesis of two well-known economic ideas. Firstly, derived from the I/O figure, which portrays the system of inter-industry linkages in the economy and despite the fact that any transaction is entered in a single cell, it appears in the accounts of two different sectors using traditional double-entry bookkeeping. Secondly, derived from national income accounting, is that income always equals expenditure.

As indicated by the name, it is a data system that includes both social and economic data for an economy. Therefore the SAM is broader than an I/O table and typical national accounts, showing more detail about all kinds of transactions within an economy. The United Nations (1999) states that compared to an I/O table, the SAM technique elaborates more on the household sector. As an extension of the I/O framework, the SAM allows one to show how the incomes of households, governments and other sectors are formed. Roberts (1991) defines social accounting analysis as a natural progression or extension of traditional input/output models, capable of focusing on a wider range of issues than those usually addressed by Leontief-type models. Similar to an I/O table, a Social Accounting Matrix (SAM) is a single-entry accounting table wherein row entries reflect receipts and column entries reflect expenditure. To ensure balance in the SAM, the underlying principal of double-entry accounting applies, i.e. for each account in the SAM, total revenue (row total) equals total expenditure (column total).

McDonald and Punt (2002) explain that the guiding principles behind the SAM are the concept of circular flow and the requirements of double-entry bookkeeping. The economic concept of circular flow, presented in Figure 2.1, represents a particular idea of economic systems. Following the flow in one direction represents the flow of goods and services, whereas the other direction represents the flow of funds. Institutions, including households, enterprise and government, act as sellers in factor markets and purchasers in commodity/product markets, whereas the opposite applies to activities. Activities, in addition, can also purchase intermediate products from the commodity markets. Transactions with the rest of the world can take place through both commodity and factor markets.

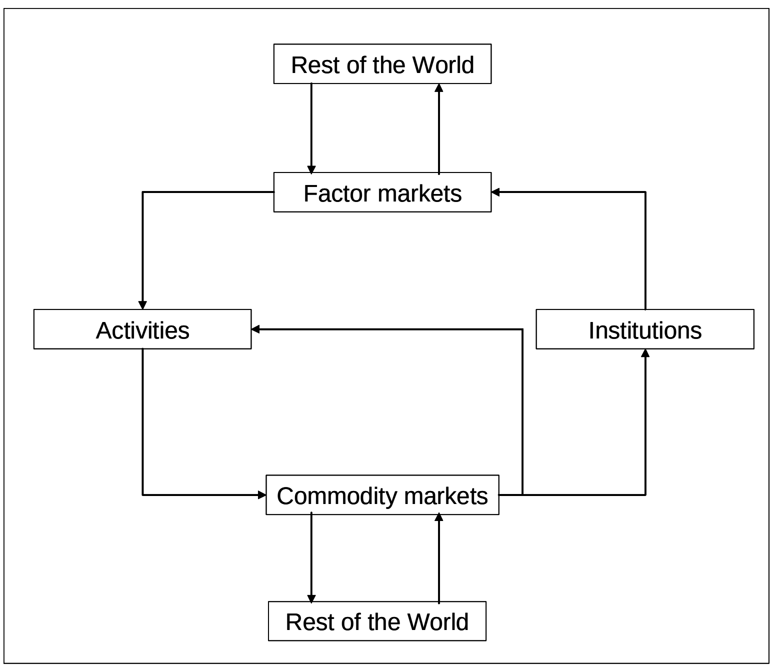


Figure 2.1: Schematic presentation of economic circular flow
Source: McDonald and Punt (2001:7)

The SAM therefore provides a conceptual basis to analyse both distributional and growth issues within a single framework. For instance, the SAM shows the distribution of factor incomes of both domestic and foreign origin, over institutional classes and the redistribution of income over these classes (Sen, 1996). In addition, Sen (1996) also points out that the SAM shows the expenditure of these classes on consumption, investment and savings made by them.

Household incomes are normally not the same as compensation of employees. The United Nations (1999) explains that household income can only be obtained after the process of distribution of income. For example, in addition to the compensation of employees, the household sector receives dividend interest on its deposits and transfers from other sectors like social security benefits. In terms of payments, households pay income taxes, interest on loans, social security contribution fines, as well as penalties and other types of transfers. The net receipts then form the disposable income (DI). Disposable incomes of other sectors are formed in a similar way. By expending these distributions and redistributions in an I/O framework, a SAM can be formed.

Despite the fact that there are many alternative layouts that can be used for constructing a SAM, McDonald and Punt (2001) explain that in general, six sets/types of accounts (all with numerous sub-accounts) can be distinguished in the SAM, including:

- commodity accounts,
- activity (or production) accounts,
- factor accounts,
- institutional accounts (households, enterprises and government),
- capital (savings/investment) accounts, and
- rest of the world (RoW) accounts.

Table 2.1 shows a typical outline of a SAM, with the **Commodity** accounts recording the demand and supply of commodities in the economy, i.e. all transactions relating to intermediate input demand, institutional consumption, as well as investment demand. The entries in the commodity row accounts show how commodities are distributed between intermediate input demand (USE matrix as shown in Table 2.1) that is used by activities and final demand. Final demand in turn is made up of consumption demand by households, governments and enterprises (if applicable). Investment and export demand from the rest of the world is also included, which represents the capital and exported commodity values. PROVIDE (2003) explains that all domestically consumed commodities are valued at the same price, which is inclusive of all relevant sales taxes and tariffs. Thus, all prices along the row are the same irrespective of which agent purchases the commodity. This is the so-called law of one price. An exception to this law of one price is the domestic price of exported commodities, which are valued at the world price of exports multiplied by the exchange rate as well one minus the export tax rate (PROVIDE, 2005b).

Activity accounts record transactions by the productive activities, therefore providing information regarding the generation of value added (production) within the economic system (represented by the MAKE matrix shown in Table 2.1).

Factor accounts represent income earned by and expenditure made by factors. Income to factor occurs from the employment thereof by domestic production activities or payments for domestically owned factors used in the rest of the world. The income that occurs to capital is usually in the form of profits and rent, while labour earns wages. Factor account expenditures, shown in the factor column, are distributed between domestic and foreign-based owners of the factors.

Institutional (organisational) accounts, including households, enterprises and government, provide information about how the institutional arrangements (patterns of property rights and preferences of the society) interact to determine the nature of transactions (final demand of goods and services) between the production accounts and institutions, as well as between institutions. McDonald and Punt (2001:14) elucidate that institutional accounts are therefore where much of the richness of economic detail provided by the SAM is recorded. The majority of institutional income is usually made up by households, which earn their income mainly from factors, but also from transfers from other institutions or the rest of the world. Household income is in turn distributed between consumption, transfers to other households, direct taxes, and savings. Enterprises earn income from non-distributed firm profits, as well as from transfers, whereas surplus income is distributed between taxes and transfers to other institutions and the rest of the world, as well as enterprise consumption and savings. Government receives income from various tax sources, from the ownership of factors (if applicable), and from transfers from other institutions and the rest of the world. Expenditure is made up of transfers and government consumption demand (PROVIDE, 2003).

Capital accounts, in short, refer to investment and it's funding. Income to capital accounts comes from savings by institutions and the rest of the world, whereas expenditures record investment that is often limited to investment expenditure (gross domestic fixed capital formation).

The **rest of the world** accounts record the trade transactions, which are important if trade policy issues are to be analysed. Imports are an income to the RoW that are associated with expenditures by domestic agents, whereas exports represent expenditures by the rest of the world, and hence an income to the domestic accounts.

Table 2.1: Typical outline of a SAM

Expenditures/ Receipts	1. Commodities	2. Activities	3. Factors	4. Households	5. Enterprises	6. Government	7. Savings/ investment	8. Rest of the world	TOTAL
1. Commodities		Intermediate inputs (USE matrix)		Private consumption		Government consumption	Investment	Exports	Demand
2. Activities	Domestic Production (MAKE matrix)								Activity income (gross output)
3. Factors		Value added						Factor income from RoW	Factor income
4. Households			Factor income to households	Inter-household transfers	Transfers to households	Transfers to households		Transfers to households from RoW	Household income
5. Enterprises			Factor income to enterprises			Transfers to enterprises		Transfers to enterprises from RoW	Enterprise income
6. Government	Sales taxes, tariffs, export taxes/	Indirect taxes, factor use taxes	Factor income to government, factor taxes	Transfers to government, direct household taxes	Transfers to government, direct enterprise taxes			Transfers to government from RoW	Government income
7. Savings/ investment				Household savings	Enterprise savings	Government savings		Balance of payments	Savings
8. Rest of the world	Imports		Factor income to RoW		Transfers to RoW	Government transfers to RoW			Foreign exchange outflow
TOTAL	Supply	Activity expenditures	Factor expenditures	Household expenditure	Enterprise expenditure	Government expenditure	Investment	Foreign exchange inflow	

Source: Löfgren, Harris and Robinson (2002)

A SAM is characterised by the disaggregated treatment of the non-production-oriented accounts, with inter-industry transactions confined to a single sub-matrix in this type of framework. Apart from the obvious extension of information, the most noteworthy difference between a SAM and an I/O table is the inclusion of both row and column entries for the various types of factors of production. These serve to map the value-added payments from the production sectors to the owners or providers of the factor services, i.e. the institutions. Roberts (1991) further emphasises that, unlike aggregate national accounts or I/O tables, the SAM highlights the issue of income distribution.

Roberts (1991) further argues that the construction of the SAM can be justified simply because of its properties as a unifying and consistent data framework. Every row and column total in the matrix must balance, leaving no room for statistical discrepancies. The construction process will identify either lack of data or data inconsistencies, whilst the finished SAM will offer a device for organising or monitoring changes in the economic environment.

SAMs constructed for CGE modelling have the production system of the economy represented by separate industry and commodity accounts: The commodity accounts collecting domestic production supplies from the industries in the so-called “make” matrix, and the industries purchasing commodities for use as intermediate inputs in the so-called “use” matrix.

One of the major weaknesses or shortcomings of SAM-based multipliers lies in the basic economic theory implying that household expenditure patterns, tax and saving rates do change with income levels. Thus, in closing the model with respect to institutional accounts, the SAM modeller is making the same, inherently incorrect, assumption as the I/O modeller who wants to include the induced effect arising from shock in the economy by presenting type II multipliers (Roberts, 1991). However the SAM’s desegregation of institutions into various household types helps to alleviate the problem.

With respect to policy analysis, the ability of the SAM model to add distributional information is important. For example, at regional level, especially in areas like the Northern Cape where agricultural activity is very prominent, an understanding of the knock-on or feedback effects of patterns of factor ownership may be important (Roberts, 1991). The objectives of the SAM are therefore twofold: Firstly, it organises the information about the economic and social structure of a country over a period of time, and secondly it provides a statistical basis for the creation of a plausible model capable of presenting a static image of the economy along with simulating the effects of policy interventions in the economy.

Robinson and Löfgren (2005) show that SAM multiplier models are typical models that have been extended to have intermediate inputs and multiple accounts for activities, commodities, factors and households. In the SAM multiplier model, equilibrium is usually defined as row-column (supply-demand) balance in all SAM accounts. Comparative static analysis with SAM multiplier models involves changing exogenous demands (column entries) and solving for the resulting changes in supplies and demands that balance all endogenous accounts. Robinson and Löfgren (2005) further explain that the term “multiplier” is used because the changes in commodity accounts are generally larger than the exogenous shock.

Similar in a sense to I/O analysis, Robinson and Löfgren (2005) state that the richness of SAM multiplier analysis comes from its ability to trace out chains of linkages from changes in production, factor incomes, household incomes and final demands. Very much like the, so-called (Robinson and Löfgren, 2005) simple Keynesian model, in SAM multiplier models unemployment is normally assumed whereas output is determined by demand. As in the case of the Keynesian demand multiplier, the SAM multiplier models can also generate a demand multiplier equal to one over one minus the marginal propensity to consume (Robinson and Löfgren, 2005).

Like the I/O model, the SAM multiplier model is simple in the sense that it does not have any supply constraints, price adjustments or explicit treatment of time dynamics. Robinson and Löfgren (2005) point out that this simplicity is also the source of weakness for the SAM multiplier model, as it is difficult to think of any real world economy without supply constraints. This weakness can be overcome by a CGE model, discussed in the next section, in that CGE models add the supply side and endogenise commodity and factor prices.

Mabugu (2005) explains that the SAM has basically two functions, i.e. descriptive and modelling. Firstly, the information contained in the SAM describes the flow of goods and payments between institutions in an economy. Secondly, each cell in the SAM, representing a transaction, can be thought of as the outcome of an underlying optimisation problem of the relevant institution(s). Mabugu (2005) elucidates that the flow in a cell can be represented by a specific functional form of relative prices and quantities (for goods and factors), as well as some exogenous factors.

By its nature, impact analysis is often directed at detailed or disaggregated sectors, which requires vastly detailed accounts. Reinert and Roland-Holst (1997) explains that the implementation of a CGE model at such a level of desegregation would be difficult numerically and would generate vast amounts of information extraneous to the issue at hand. To overcome this, a "flexible aggregation" approach can be used. The base SAM is initially estimated for as many sectors as possible to address a broad spectrum of detailed industry issues. For a particular application, these detailed sectors that do not bear on the current problem are aggregated into fewer broad sectors.

2.2.4 Impact analysis

In short, impact analysis is a means of empirically estimating the consequences of an exogenous change (shock) on the economy or sector/industry in particular. Impact analysis is normally focused in two directions, i.e. the impact of other activities on the industry under investigation, as well as the impact of that industry on other industries. Policymakers want to see how a particular industry will evolve in the future so that they can plan accordingly. In addition, policymakers also want to see the importance of that industry in the economy in terms of how much employment, income and taxes it generates and also what capital and imports it needs to grow.

With full-fledged impact analysis, i.e. initial and total impacts, it is not possible to isolate the total impact of a particular industry on the whole economy when calculating its impacts. Impact analysis of an economic problem would make sense only if it can be formulated consistently as changes in the vector of final demand, i.e. changes in final consumption, exports, fixed capital formation (i.e. investment on capital goods) and inventories (United Nations, 1999).

For any type of impact analysis it is important to differentiate short-term from long-term effects. For example, an increase in fixed capital investment is mostly of a short-term nature, and the effects will disappear when the production of goods and services for the investment project is suspended. The long-term effects would be replacement investment, maintenance and operating expenses to sustain new production activities created by the project.

Hussain, Jafri, Buland and Randals (2003) explain that **direct effects** are the initial immediate effects caused by a specific activity that will subsequently initiate a series of iterative rounds of income creation, spending and re-spending, resulting in indirect and induced effects. The **indirect effects** are those changes to production, employment and income resulting from the direct effect on industry sectors that may be directly or indirectly related to the initial impacted sector. The **induced effects** include the general change in the household sector's earnings and spending patterns as a result of the direct and indirect effects. Together these three effects/impacts constitute the total effects, whereas leakages are defined by Hussain, Jafri, Buland and Randals (2003) as those expenditures that "leak" out of a specific area and cannot be included in an estimation of the total impact at local level.

Hussain *et al.* (2003) lists other types of, which are more *ad hoc*, impact analysis methods including: multipliers (multiplier analysis), backward and forward linkages, as well as the use of a Social Accounting Matrix (SAM).

2.2.5 Multiplier analysis

The relationship between the initial spending and the total effects generated by the spending is known as the multiplier effect of the sector, or more generally the impact of the sector on the economy as a whole. For this reason the study of multipliers has come to be called impact analysis (O'Connor and Henry, 1975). Hussain *et al.* (2003) define a multiplier as a numeric measurement expressed as a mathematical ratio of the total effects (including the direct, indirect and induced effects) to the direct effects of a specific activity or a change in some activity. This implies that a multiplier of 1.6 indicates that for every R1 spent (direct expenditure) an additional R 0.6 is generated within the economy.

Multipliers measure the total effects on output, employment or value added, given an increase of one unit in output of a particular industry (United Nations, 1999). Types of multipliers include input, output, income and employment multipliers. Income and employment multipliers are interpreted in the same way, i.e. they show the total increase (decrease) in income or employment given an increase (decrease) of one unit of output of each industry.

Multipliers can be used for both micro and macro analysis. At micro level (regional level for example), multipliers can be used as indicators assessing the variation in effects for a particular activity. However, if multipliers are used as criteria for development for the whole economy (macro analysis) for example, there is a tendency to conclude that depending on society's objective, the industry with the highest multiplier (and that industry alone) will be selected for development (United Nations, 1999). This type of conclusion can lead to the misuse of multipliers.

O'Connor and Henry (1975) explain that despite being able to trace the idea of multipliers back to the 1931 work of Kahn, the modern concept of an income multiplier is usually associated with John Maynard Keynes. Keynes' work can be described as a unit increment of autonomous investment causing an initial increase in income, which generates successive rounds of consumer spending and incomes – each round producing numerically smaller increments until the process has worked itself out, i.e. has reached equilibrium. What is typically found, according to the work of Keynes, is that the fully worked-out response to the stimulus produces in the first instance savings equal to the initial investment and secondly consumer spending that is considerably larger than the initial unit increment of investment.

Layman (2000) explains that multipliers are often used to illustrate the significance of an industry or activity in the overall economy. He also points out that in many cases, multipliers are presented as evidence to support claims for taxpayer funding to assist or promote particular activities over others. It is for this reason that Layman (2000) warns against the shortcomings of multipliers so that they can be used with caution, and therefore not be abused.

Despite numerous classifications of multipliers, three classes are patently prominent in the literature, including output, income and employment multipliers. In summary, an output multiplier (most frequently quoted) shows the increase in the total production of all industries in the economy from an external increase in final demand for a particular industry under investigation. Similarly, income and employment multipliers show the increase in economy-wide income and employment respectively from an external increase in demand.

Layman (2000) explains that in essence there are two major types of multipliers. On the one hand, **partial or simple multipliers (type I)** comprise the initial output effect plus the first-round effect and the industrial support effect, where the latter two effects are often referred to as the production-induced effects. The difference between the initial output effects and the first-round effects is that the initial effects are simply – as the name indicates – the initial production, employment or income required to supply the extra final demand for the industry in question. First-round effects measure the demand for intermediate goods and services generated by the initial industry increasing production.

On the other hand, **total or complete multipliers (type II)** in essence comprise the aggregate of the simple/partial multiplier and the consumption-induced effect. Consumption-induced effect refers to additional induced consumption from households as a result of increases in income and wages due to increased economic activity. Households must therefore be included in the inter-industry section. O'Connor and Henry (1975) further explain that when this is done, the household income is treated as being within the system and as generating further economic activity.

Numerous other partial multipliers can be obtained. Import multipliers, for example, show the import requirements of a unit of final demand for the produce of each sector and how the balance of trade is affected by a specific increase in the final demands for the products of the different sectors.

Layman (2000) shows that despite the fact that multipliers are relatively simple to calculate once an I/O table of the economy is compiled, there are basically five aspects that substantially reduce their usefulness as a tool for evaluating the benefit to the overall economy. Firstly, multipliers assume that extra output can be produced without constraints of the supply of the labour, land, capital goods or services. These factors of production are assumed to be limitless in supply and therefore can be sourced without any price increase meaning that there are no "crowding out" effects. In reality, if factors are short in supply, prices are expected to rise and therefore reduce the flow-on effects of increased activity.

Secondly, multipliers assume that households consume goods and services in exact proportion to their initial budgets. The problem with this is that no allowance is made for the consumers' marginal preferences. For example, the household budget share of a particular good or service might change as a result of a change in the disposable income. Layman (2000) also indicates that this problem applies to industrial consumption of intermediate and primary factors.

Thirdly, an increase in the demand for a product implies an equal increase in the production thereof. In reality, however, if local demand increases, it might be more efficient for industry to divert some exports to local consumption or to import to some extent rather than increase the local production.

In the fourth place, multipliers are often misinterpreted (misused) when evaluating industry assistance proposals, because they refer to changes in the economy caused by a change in the final demand for a product. However, requests for government assistance are usually framed in terms of increasing the production of the industry. It is therefore often found that the aggregate benefit to the economy is likely to be less than the inference of the multiplier if a price cut is required to sell the extra production.

Finally, if government subsidy is required to propel an industry to a higher output, then multipliers do not include the cost of the subsidy on the rest of the economy.

In addition to the five listed limitations, Layman (2000) also remarks that due to data limitation, the ranking of various industries on the basis of their output and employment of income multipliers is not particular meaningful. The reason for this is that the accuracy of typical I/O tables is not sufficient for industries with very similar multipliers to be ranked on merit according to these multipliers.

2.2.6 Backward and forward linkages

Backward and forward linkages of an industry are meant to measure the inter-industrial linkages of a particular industry to other industries as a supplier of inputs (i.e. backward linkages) and as a provider of inputs to other industries (i.e. forward linkages). These concepts are usually applied in the context of studying development strategy (United Nations, 1999).

Jones (1973) explains that the backward linkage effect can be seen as the derived demand or input provision that a non-primary economic activity induces via the inputs needed in that activity. Forward linkages in turn are the output utilisation induced by activities that do not by nature cater exclusively to final demands as inputs in some new activities.

2.2.7 Computable General Equilibrium (CGE) model

Computable General Equilibrium (CGE) models are a class of economy-wide models widely used in policy analysis (Löfgren, Harris and Robinson, 2002). Robinson and Löfgren (2005) remark that since the late 1970s, real CGE models have provided the dominant framework for economy-wide, multi-sectoral models. Löfgren *et al.* (2002) explain that recent improvements in model specification, data availability and computer technology have improved the payoffs and reduced the costs of policy analysis based on CGE models, paving the way for their widespread use by policy analysts throughout the world. In essence, CGE models describe an economy by using a system of equations representing the behaviour of producers, consumers and government, as well as other role players.

Löfgren (2000a) explains the meaning of the term CGE as follows: The term **Computable** refers to the fact that the model solution can be computed, which is a prerequisite when a model is used for applied purposes, i.e. real data is used and solved on a computer. It is **General** in the sense that the model represents the behaviour of not just one type of economic agent, but all types of agents in the economy. By **Equilibrium** it is implied that an exogenous change (from a policy shock or some other source) that affects any one part of the economy can produce repercussions throughout the system, i.e. the solution of the model is the set of prices and quantities that no agent has an incentive to change.

Dixon, Parmenter, Powel and Wilcoxen (1992) explicate that **General Equilibrium** therefore refers to an analytical approach that looks at the economy as a complete system of interdependent components (industries, households, investors, governments, importers and exporters), implying that the production and consumption sides of the economy in question are determined concurrently. It is for this reason that CGE models are preferable to partial equilibrium models for understanding/quantifying possible impacts from exogenous shocks. Dixon, Parmenter, Powel and Wilcoxen (1992) further convey that applied CGE modelling means that the primary interest is in systems that can be used to provide a quantitative analysis of economic problems in a particular country. Applied CGE modelling can therefore be seen as a powerful technique for quantitative analysis of the effects on industries, government, regions, occupations and households of changes in a myriad of variables including taxes, trade restrictions, government expenditures, welfare policies, commodity prices, technology, and environmental regulations (Dixon *et al.,* 1992).

Capros, Karadeloglou and Mentzas (1990) elucidate that the theoretical framework of CGE models is well known from micro-economic theory: In an assumed perfectly competitive economy in which each economic agent behaves as a price taker, there exists a set of prices that satisfy the objectives of agents in an optimum manner and lead all markets to demand-supply equilibrium. The set of homogeneity assumptions implies that only relative prices affect the equilibrium conditions.

Kilkenny and Robinson (1990) state that CGE models are appropriate for analysing a variety of macro-economic issues, because they include factor markets, government accounts, and the major macro balances. They go on to point out that firstly, the advantage that CGE models have over econometric models lies in their consistency and the fact that they are sectorally disaggregated. Secondly, in contrast to the partial equilibrium model, the economy-wide nature of CGE models further enhances the realism.

In terms of the detail at macro level, CGE models differ considerably in size, time horizon and the nature of the macro equilibria they incorporate. Robinson and Löfgren (2005) explain further that at the meso and micro levels, CGE models vary in terms of the approaches they use to generate information about poverty and inequality. The term "meso" (intermediate or middle) refers to the level between macro economics and micro economics at which the typical CGE model disaggregates the economy into activities, commodities, factors and institutions, in which the number of elements is more than one but fewer than the full number of agents in the economy observations in the survey (Robinson and Löfgren, 2005). As a result of these differences, the "domain of applicability" amongst CGE models also differs widely. CGE models have evolved over time as powerful tools to assess hypothetical as well as actual policy changes within a real world data framework (Van Tongeren, Van Meijl and Surry, 2001 and Hertel, 2002).

Löfgren (2000a) explains that mathematically, a CGE model consists of a set of simultaneous nonlinear equations, whereas economically its starting point is Walras' neoclassical world. Being Walrasian in spirit, a classical CGE model incorporates all flows in a SAM, including production, distribution and demand, as well as the process of determining equilibrium wages and prices by simulating the operation of all markets (Robinson and Löfgren, 2005). Robinson and Löfgren (2005) describe the key actors in CGE models as being producers and households. Producers on the one hand maximise profits given the available technology, output prices and factor wages. Households on the other hand maximise their utility subject to a budget constraint determined by market prices and factor endowments

The range of issues on which CGE models have had an influence is quite wide, and includes structural adjustment policies, international trade, public finance, agriculture, income distribution, and energy and environmental policy (Devarajan and Robinson, 2002a). In Table 2.2, the three main uses and misuses of CGE models are listed. According to Devarajan and Robinson (2002a) evidence from empirical applications points out that cases where CGE models have enlightened the policy debate can be ascribed to uses listed in Table 2.2, whereas they also warn against the misuse of CGE models in policy analysis.

Table 2.2: Main uses and misuses of CGE models

Uses	Misuses
Consistent results from CGE models and other types of analysis	Pushing the model beyond its domain of applicability
CGE models capture particular features of the economy	Using the simplest model suited to the task (violation of Occam's razor principal)
CGE models provide a consistent framework to assess linkages and tradeoffs among different policy packages	Results whose link with the policy change is opaque (black box syndrome)

Source: Devarajan and Robinson (2002a)

The main form of analysis based on CGE models is that of comparative statistics, where one starts with a base solution/scenario, after which one of the exogenous variables/parameters is altered, and the model then computes the new values for the endogenous variables. The comparison of the two sets of values of the endogenous variables suggests the estimated economic impact of the change in policy or intervention (Mabugu, 2005). Comparative statistics therefore differ from dynamic analysis in the sense that dynamic analysis is rather concerned with looking at the path from one equilibrium to another, which is oft ignored in comparative statistics.

Reinert and Roland-Holst (1997) further explain the role of the SAM and flexible aggregation in supporting the CGE modelling of trade policy on the basis of Figure 2.2. The fully disaggregated base SAM is denoted as SAM I, whereas the initial exogenous behavioural parameter estimates are denoted by EPE I. In the aggregation procedure, the information in the disaggregated database is used to create a second SAM (SAM II) and corresponding parameter set at the level of aggregation specified for a given analysis. SAM II is then used as the benchmark equilibrium to calibrate the CGE model. Following the calibration of the SAM, there is an exogenous counterfactual policy change or shock, and the behavioural model simulates the response of the economy. These results in the counterfactual equilibrium can then be expressed in a new SAM, namely SAM III. In this way, the modelling exercise begins and ends with a SAM.

In a survey conducted amongst 73 CGE applications in 26 developing countries (excluding South Africa), Decalwe and Martens (1988) found the phenomenon consistent with the overall observation that policymakers are increasingly relying upon the working of market forces and incentives rather than putting faith in the outcomes of centrally planned allocation procedures. Decalwe and Martens (1988) go on to state that, given their theoretical framework, CGE models are indeed better suited to simulating decentralised economic policies than alternative forms of modelling, such as linear programming and other resource-gap models, which have traditionally constituted the mathematical underpinnings of central economic planning. According to Decalwe and Martens (1988), in most CGE models found in the literature only relative prices matter, while producers are profit maximisers facing non-increasing returns to scale, consumers are insatiable utility maximisers, and production factors are paid according to their marginal-revenue productivity. The model's solution provides a set of prices which, by making all these individual optimisations feasible and mutually consistent, clears all markets simultaneously.

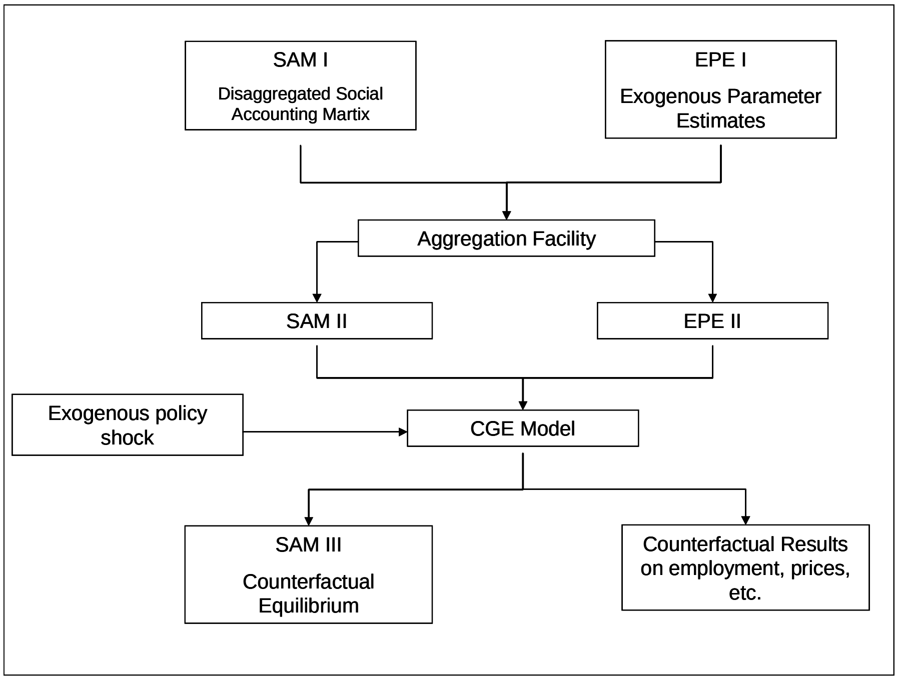


Figure 2.2: The flexible aggregation procedure
Source: Reinert and Roland-Holst (1997)

2.2.8 Difference between macro-econometric and CGE modelling approaches

Capros *et al.* (1990) explain that the role of applied models has always been pervasive in the formalisation of macro-economic policy strategies. On the one hand, macro-econometric (ME) and CGE modelling paradigms can be seen as the two most prominent in this field. According to Capros *et al.* (1990) ME models retail their prestige for year-by-year forecasting, as well as the analysis of short- and medium-term policies; nevertheless, ME models lack the ability to adequately simulate the long-term character of the restructuring and distributional effects of exogenous shocks or policies. Capros *et al.* (1990) go on to point out that the majority of ME applications refer to the industrial and developed world. CGE models, on the other hand, have proven to be an ideal tool for studying income distribution and resource allocation and for analysing the restructuring effects of alternative policy measures. In contrast to ME, Capros *et al.* (1990) mention that the bulk of CGE models refer to developing and Third World countries.

2.2.9 Advantages of SAM-CGE framework

The use of Computable General Equilibrium (CGE) models is seen as a valid alternative to using I/O multipliers to evaluate the costs and benefits of industry-assisted proposals or expected changes. McDonald and Punt (2001) elucidate that two basic important distinctions between a

SAM and a conventional I/O table are prominent. Firstly, the SAM captures the full circular flow (explained above), whereas the I/O table only captures part thereof. More specifically, the I/O table does not record details of the interactions in factor markets, i.e. there is no functional link between activities and institutions via factor markets. Consequently, exogenous changes in commodity demand resulting in an increase in economic activity are not translated into increases in factor incomes to institutions via the factor markets, and hence into increases in endogenously determined commodity demand by institutions. Secondly, the I/O table does not record the transactions between the various institutions in an economic system, or between the various components of an economic system and the rest of the world, with the exception of commodity transactions.

Dixon *et al.* (1992) portray modern applied general equilibrium models to include a range of interdependencies wider than just those arising directly from the flow between agents in the economy. More specifically, modern CGE models include interdependencies arising from the constraints that bind the economy as a whole. Demands for labour, capital, foreign exchange and other resources in one part of the economy affects all other parts via movements in factors prices and the exchange rate and via other induced changes in the costs of all goods and services. Dixon *et al.* (1992) further clarify that models attempting to capture all these interdependencies require two types of data, namely input/output (I/O) tables and behavioural parameters. Firstly, I/O tables record commodity flows between components of the economy for a single period in time, whereas behavioural parameters summarise how agents respond to changes in activity variables and prices. Behavioural parameters can, for example, describe how producers adjust their demand for inputs in response to changes in their output levels and input prices, or how households adjust the level and composition of their consumption in response to changes in their incomes and in consumer prices (Dixon *et al.,* 1992).

Layman (2000) explains further that CGE models in most cases overcome the problems with traditional I/O multipliers as outlined above. For example, when assessing industry assistance proposals in CGE models, taxes on other industries can be increased to fund a subsidy for a particular industry. In recent years the use of CGE models in assessing policy impacts has increased considerably. However, Layman (2000) warns that the greatest disadvantage of using CGE models is that the level of expertise and resources needed to operate these models is far greater than that required when it comes to using I/O multipliers.

According to Mabugu (2005) the principal advantage of using CGE models in policy analysis, for example, is that it permits one to take into account interactions throughout the economy in a consistent manner.

Given the ability of CGE models to link the macro and micro levels and account for how incomes and consumption in different household groups are affected by economic shocks and policy changes, CGE models provide an attractive and natural framework for macro-poverty analysis (Robinson and Löfgren, 2005).

2.2.10 Econometric critique of CGE modelling

Despite stating that CGE models are amongst the most influential tools in applied economics, McKitrick (1998) points out that some serious questions have been raised about the empirical validity of these models. According to McKitrick (1998) the econometric critique of contemporary CGE modelling states (among other things) that the calibration approach leads to over-reliance on non-flexible functional forms. By presenting a comparative CGE modelling experiment, McKitrick (1998) assessed the role of functional forms in a series of comparative simulations and found that functional form affects industry-specific results, as well as aggregate (macro-economic) results in both large and small policy shocks. McKitrick (1998) therefore emphasises that first-order functional forms in CGE model play an important role in the results that will be obtained.

2.2.11 Schools of thought

From reading the literature (Robinson and Löfgren, 2005) and personal communications with experts – including Roe (2005), Smith (2004) and Bayar (2005) – three schools of thought seem to be apparent in macro-economic modelling, namely the orthodox school, the eclectic school, and the ecumenical school.

Robinson and Löfgren (2005) advise that, when designing or choosing among different modelling frameworks, it is important to consider the users of the analysis, the structure of the economy being modelled, the availability of data, as well as issues (policy, etc.) of interest. *Ceteris paribus*, simpler models are always preferred to more complex ones, because they are easier to use, adjust and understand, making their findings more convincing.

2.2.11.1 Orthodox school

According to Robinson and Löfgren (2005) the orthodox school views the Walrasian CGE model as theoretically elegant and complete. Any attempt to add additional macro features and financial variables simply corrupts it. This school of thought applies CGE models only to analyse issues of allocative efficiency, relative prices, and the structure of employment, production and demand in an environment of well-functioning markets using a model that stays true to a Walrasian view of the economy. As indicated by Robinson and Löfgren (2005:273), this line of thinking is becoming less influential and is clearly less relevant in the context of macro-poverty analysis.

2.2.11.2 Eclectic school

According to Robinson and Löfgren (2005) the eclectic school is very active and more “open minded”, and has grown in influence during the past decade. This school of thought builds integrated models that incorporate the best elements from Walrasian CGE models and selected macro and financial models. An advantage of these multi-sector CGE models is that they can be used to provide the supply side of a dynamic macro-CGE model that is much richer and which includes assets, interest rates, inflation, expectations, and other macro-economic features.

2.2.11.3 Ecumenical school

The ecumenical school of thought differs from the other two schools of thought in the sense that it keeps the CGE and macro-financial models separate, but specifies ways in which the models can “talk” to one another. For example, the models can communicate via a variable that is endogenous to the one model, but exogenous to the other. A major advantage of this kind of approach, according to Robinson and Löfgren (2005), is that in separating the two modelling frameworks, modellers tend to avoid mixing the two paradigms in a single model.

2.3 EMPIRICAL MACRO-ECONOMIC IMPACT STUDIES AND MODELS

2.3.1 Input/Output (I/O) models and variants thereof

Johnson and Kulshreshtha (1982) analysed the impact of change in agricultural enterprise mix on the aggregate economy of Saskatchewan, Canada, by estimating the direct, indirect and induced effects in a rectangular input/output framework. Johnson and Kulshreshtha (1982) explain that a rectangular I/O model differs from the square model in that sectors and commodities are identified separately with no requirement regarding the correspondence between the two classifications. The number of commodities may therefore be greater than, less than, or equal to the number of sectors. According to Johnson and Kulshreshtha (1982) many analysts use different names for the same multiplier, which results in a great deal of misunderstanding surrounding the concept of multipliers. From the empirical estimations, Johnson and Kulshreshtha (1982) conclude that the various farm types (sectors) do not have profoundly different effects on the aggregate levels of output, income or value added when compared on a per-dollar-of-output basis. In addition, Johnson and Kulshreshtha (1982) also point out that the multipliers for the agricultural sub-sectors are large in comparison with those of other sectors. However, the study by Johnson and Kulshreshtha (1982) failed to indicate the relative impact that different agricultural sectors have on specific non-agricultural sectors such as finance, trade, feed manufacturing, etc.

In order to estimate the impacts of projected increased pumping cost for irrigation agriculture due to groundwater depletion caused by the expanding urban area of San Antonio, Texas, Lee, Lacewell, Ozuna and Jones (1987) applied linear programming (LP) and regional I/O models in the form of the IMPLAN model. They found significant local (county-level) economic impacts from groundwater mining, but insignificant regional impacts. It was also shown that major improvements in irrigation efficiency would be required to offset the increased pumping costs and reduced water availability associated with increased lifts due to urban expansion. Lee, Lacewell, Ozuna and Jones (1987) developed the LP model, with the objective of maximising the net returns to land, labour and water, in order to evaluate the impact of four alternative groundwater scenarios on agriculture. Based on 1979 data, the location quotient technique was used to develop an I/O model for the study area including 34 processing sectors, 7 final-demand sectors, and 6 final-payment sectors. Lee *et al.* (1987) then applied the interdependence coefficients for irrigation agriculture to the changes in gross revenues from the LP model to adjust the total output vector of the regional I/O model. It was found that irrigated agriculture was responsible for over 5% of the economic activity in Uvalde County compared to only 0.03% in the San Antonio region.

Kirsten and Van Zyl (1990b) reported on a study that estimated the economic impact of irrigation agriculture in the south-western Free State. Five fundamentally different methodologies for economic impact studies, including economic basis study, input/output models, econometric models, mathematical programming models, and the comparison of regions methodology, were investigated (Kirsten and Van Zyl,1990b). Given the goals of their study and the availability of data, the I/O technique was chosen as methodological approach for the study (Kirsten and Van Zyl, 1990b). Furthermore it was discovered, by investigating several international case studies on the subject, that I/O techniques are more common and applied with greater success, especially when detailed impact information is required. Kirsten and Van Zyl (1990a) also explain that the purpose and motivation of such an economic impact study influences the model (methodological) choice. Where linkages between different sectors in the regional economy are important, the I/O analysis has proven to be the most suitable method.

Kirsten and Van Zyl (1990a) list four methods that can be used in the compilation of regional I/O tables: Firstly, the product-based method, which distinguishes between products and sectors/activities. Secondly, a survey method is one where the I/O table is compiled based on primary data collected via surveys. Thirdly, a non-survey method uses shortcuts by deriving the regional table from the national I/O table. The fourth and most recent method is the so-called semi-survey method, (used by the authors to compile the regional I/O table for the south-western Free State), where in order to distinguish between agriculture and irrigation agriculture, separate sets of multipliers for irrigation agriculture were used together with a mailed survey from irrigation farmers in the region.

Kirsten (1989) used a semi-survey method based on the product balance approach developed refined by Mohr and Van Seventer (1988) to compile an I/O table for the south-western Free State. Various sources of information, including primary and secondary information, were used when compiling these tables. Due to the fact that the irrigation agriculture sector was specifically the focus of the analysis, more accurate information on the sector from the 1985 agricultural survey was used. A separate set of multipliers for irrigation agriculture was calculated in order to determine the economic impact thereof. Kirsten (1989) also states that it is necessary to distinguish between irrigation agriculture and the rest of agriculture in the I/O table in order to be able to calculate these required multipliers.

Kirsten (1989) distinguishes between three sets of multipliers, namely output, income and employment multipliers. For each of these multipliers, Hewings and Jensen (1986) distinguish between six multiplier effects, namely i) initial impact, ii) first-round effects, iii) secondary effects (industrial support effects), iv) consumption-indigenised effects, v) total effects (multipliers), and vi) flow-on effects. The output multiplier is the response (in terms of output) in rand value of the economy in reaction to a R1 change in the demand for output of a specific sector. According to Kirsten (1989) the total output multiplier of irrigation agriculture in the south-western Free State is 1.7. This implies that for each R1 production/output of irrigation agriculture, there will be an additional output to the value of R0.7 generated in the intermediate sector, final demand by households, as well as exports within the region. Stated differently, Kirsten (1989) remarks that a R1 production of irrigation agriculture will result in a R 1.7 increase in the output of the regional economy. It is clear that the flow-on effects, as calculated by Kirsten (1989) for irrigation agriculture in the south-western Free State in terms of the output, amounts to R0.7. Irrigation agriculture therefore generates an additional output to the value of 70.1 cents in the other remaining sectors of the regional economy. Table 2.3 shows the sectors to which the flow-on effects from irrigation agriculture flow. It is clear that the largest proportion of the flow-on effects flows to the trade sector (42.3%) followed by electricity (14.2%) and transport and communication (12.8%). It is furthermore also clear that only a small, insignificant share of the flow-on effects occurs due to the manufacturing of food, textiles and drinks (1.2%) within the region.

Kirsten (1989) calculated the total income multiplier as R0.153, of which R0.069 represents the initial impact and the remaining R0.084 the flow-on effects. In terms of the employment multipliers, Kirsten (1989) calculated it as 89.6, indicating that for each R1 million worth of output produced by irrigation agriculture, 89.6 persons are employed, with 67.8 persons being employed in the irrigation agriculture sector itself. Kirsten (1989) also calculated the total economy-wide impact of irrigation agriculture in the region, with the direct impact of irrigation agriculture in the region being R20.1 million in terms of output, whereas salaries and wages amount to R1.39 million paid to households, represented by 1366 persons. The total impact on the economy as a whole is R34.3 million in terms of output, 1 806 job opportunities, and total household income of R3.1 million that can be linked directly and indirectly to irrigation agriculture in the south-western Free State.

Table 2.3: Sectoral composition of flow-on effects

Sector	Flow-on effects (cents)	Percentage (%)
Rest of agriculture	4.04	5.76
Irrigation agriculture	5.34	7.62
Manufacturing of food	.77	1.09
Manufacturing of drinks	.07	0.09
Manufacturing of textiles	.01	0.01
Manufacturing of non-metals	.57	0.81
Electricity	9.98	14.23
Construction	.25	0.35
Trade	29.66	42.29
Transport and communication	9.00	12.84
Financing	4.72	6.73
Community service	5.71	8.14
TOTAL	**70.12**	**100**

Source: Kirsten (1989)

Van Seventer and Van Niekerk (1991:45) analysed sectoral market imperfections by means of an I/O table together with "price or use-side" and "cost-side" arguments in order to determine a single value measure. The data used included I/O tables for 1971, 1975, 1978, 1981 and 1985. Aggregate I/O tables were employed with the main purpose of introducing the procedure rather than extensively analysing the results (Van Seventer and Van Niekerk, 1991). A general remark made is that the effect of market-clearing forces in South Africa are relatively underdeveloped compared to the economies of Holland and Hungary for example. In addition, the effects of government intervention at sectoral levels are visible in agriculture, food processing and electricity, which may have resulted in consistent undervaluation of their respective commodities. Sectors where overvaluation has been suggested include trade, finance, basic metals, community services and construction, with reasons relating to supply constraints and tendencies of market concentrations listed under possible problems.

Since the 1980s a number of attempts have been made in South Africa to estimate regional I/O tables at specific sub-regions (including Mirrilees, 1984 and IDC, 1997) or provincial (Van Seventer, 1999). The first interregional input/output (IIO) model for the RSA, with the advantage of the distinction between transactions taking place between and within regions, was compiled by Nel and Vivier (1995). Nel and Vivier (1995) define an IIO table as a more comprehensive form of the national I/O table, which typically emphasises the relations between regions, between enterprises, as well as between enterprises in different regions. According to Nel and Vivier (1995) the disadvantage of a standard national I/O table is that the interregional transactions, which are typically greater in value terms compared to the intraregional transactions, are not accounted for. Where official data was insufficient to complete all entries of the IIO table, Nel and Vivier (1995) applied the Leontief-Strout and RAS methods to fill these gaps. Eckert and Van Seventer (1995) used and extended a multiregional I/O model by means of a mixed multiplier model in order to inform policy decisions in the Western Cape. Brixen and Tarp (1996) simulated the effect of exchange rate devaluations, external borrowing by the government, and higher international reserves by applying the IMF's financial programming model and the World Bank's revised minimum standard model to the South African economy.

Due to the growing need for quantitative analysis of the agricultural sector Eckert, Liebenberg and Troskie (1997a) developed a SAM for the Western Cape as part of the Strategic Macro and Micro Modelling (SM3) project of the Department of Agriculture in the Western Cape. Various provincial multipliers had been calculated by Eckert, Liebenberg and Troskie (1997b, c), who followed the semi-closed I/O approach proposed by Wang and Mullins (1988). Eckert, Liebenberg and Troskie (1997c) explain that due to the dominance of provincial expenditure by coloured and black populations on fresh and processed farm commodities, future demand growth will depend on income increases among these household groups. Eckert *et al.* (1997c) further found that on aggregate, commercial agriculture's contributions to job creation, value-added and government revenue significantly exceed those of the non-agricultural sectors, whereas agribusiness exceeds other non-agricultural sectors because of backward links to primary agriculture. Within agriculture, the horticulture and livestock sub-sectors contribute the most towards the macro-economy, with nine horticultural enterprises and broilers comprising the top ten sectors in terms of their macro-economic contributions.

Hassan (1998) summarises the major modifications as proposed in the new water policy as follows: ownership, user rights, unity of the water cycle and interdependencies of its elements, conservation and demand management measures, access to basic water services on an equitable and economically sustainable basis, and integrated catchment management. In this context, two alternative policy simulation scenarios were analysed, i.e: Firstly, where no substitution in supply adjustments is allowed, and secondly, where substitution in supply is indeed allowed. For both scenarios, three possible versions were evaluated:

a) The effect of removing 100% of the water subsidy from mining and 50% from irrigation agriculture and white households while maintaining forestry, dry-land agriculture and other households' subsidies. In addition, water demand by other households was doubled.
b) An additional 50% reduction in the water subsidy to forestry and other households.
c) An additional 50% reduction of the water subsidy to dry-land agriculture and a threefold increase in other households' demand for water.

Hassan (1998) showed in the results that the overall economic impact of the three versions of scenario 1 on the total economic output as being less than 1%, whereas the impact on individual sectors varies significantly. The most affected sectors were irrigated crops and mining, but the reduction felt were less than the initial full shock (Hassan, 1998). Hassan (1998) explains this as due to the offsetting effects of the high gains from increased income to water supply that exceeded 60% net increment. Hassan (1998) further also shows that Manufacturing gained from the water policy adjustment with an 0.5% increase, indicating a much stronger linkage between the water sector and the industrial sector than the linkage with the other affected sectors (Hassan, 1998). In the case where substitution was allowed, Hassan (1998) explains that the overall impact on the economy was positive, leading to a 1% increase in total economic output.

Van Seventer (1999) applies the location quotient technique to derive interregional tables for each province of South Africa. In addition to the applications and usefulness of I/O tables, he briefly discusses the reasons for the lack of regional data in South Africa. The absence of more recent (up to date) regional or provincial I/O tables is due to the fact that the Central Economic Advisory Service (CEAS), which was a leader institution in compiling and applying regional data, closed its doors during the mid 1990s. Region-specific information on intermediate inputs for manufacturing industries was compiled by Central Statistical Services (CSS) on request of the CEAS. Similar data for the primary sectors, agriculture and mining was obtained by the CEAS from the National Department of Agriculture (NDoA) and the Chamber of Mines respectively. Final demand components were estimated by means of household survey materials from the Bureau of Market Research (BMR), government budgets, and other unpublished sources.

Kebede and Ngandu (1999) assessed the economic impact of the Mercedes Benz investment in the state of Alabama in the United States of America using the IMPLAN model (similar to Lee *et al.,* 1987). The results indicate significant direct and indirect impacts on the state's economy during the construction phase, with an even greater economic impact at full production capacity. Kebede and Ngandu (1999) further point out that the impact can be maximised by increasing the value of the local purchase of automobile parts, which further confirms the link between firm location and economic growth.

The regional I/O tables that were compiled using the data described above are consistent with CSS's national I/O table for the year 1993. Van Seventer (1999) used these tables, which were released in unpublished format, as a starting point for the compilation of a system of provincial I/O tables for South Africa. Van Seventer (1999) further explains that the attempt is modest in the sense that it is limited to the development of a consistent set of provincial I/O tables in which the relevant region or province is pitched against the rest of the country in a two-region framework. He also points out that the main challenge in such a framework is the estimation of the locally supplied component of each intermediate and final demand delivery, whereas by definition, the rest are imported from the rest of the country. Van Seventer (1999) points out that those significant differences (residuals) are found in the unpublished data of the CEAS. For this reason he applied a method, namely regional coefficients, to determine the fraction of regional inputs locally supplied and thereby eliminate part of the residuals.

In a quasi-input-output framework, Hassan (2003) measured and compared the economy-wide benefits (direct and indirect) from subtropical fruit, cultivated forestry plantations, as well as sugar cane in the Crocodile River Catchment. In addition to the backward and forward value added in the primary, secondary and tertiary industries, he described the total economic benefits from water use by the sectors under investigation in terms of employment benefits (direct and indirect jobs) created. Hassan (2003) therefore aimed to reveal the total social and economic value generated from using water in the compared alternative economic sectors. From the empirical results, Hassan (2003) found that in terms of the economic benefits directly generated, irrigated mango and orange production dominates other production activities, followed by the production of pine timber. Adding the backward and forward linkages to the direct effects, the comparative position of the sectors under investigation changes significantly, with the production of pine timber generating the highest total benefits, followed by gum timber. Hassan (2003) found the positions of the subtropical fruits to change drastically compared with sugar cane farming and forest plantations when the indirect benefits were accounted for – the reason for this being that subtropical fruits undergo very little processing beyond the farm gate compared with the various timber and sugar processing chains. Hassan (2003) also points out that a similar trend is observed when considering the direct and indirect employment benefits.

In analysing the effects of EU dairy policy reform, Helming and Peerlings (2003) applied a regionalised agri-environmental, partial equilibrium, mathematical programming model of agriculture supply in the Netherlands integrated into a mixed input/output model. Among the main findings presented include the fact that the decoupling of direct income payments stimulated milk production following milk quota abolition. Despite milk production being restricted by nutrient and manure policies in the Netherlands, and a limited effect on Dutch GDP, the income effects for individual industries can be large. It is furthermore shown that the economy-wide effects for non-agricultural industries exceed changes for agriculture.

During 2001, Erath County (Texas) produced 27% of the total milk production, representing 79% of the total agricultural income within the state (Hussain *et al.*, 2003). By means of surveys, together with an I/O model, the following questions were examined: What impact does the dairy industry have on the local economy and on the state of Texas, how many new jobs are created, and how much new income and wages in the area is added by the presence of the dairy industry in the region? The authors explain that I/O models attempt to estimate the large economic impacts of policies that occur through forward and backward linkages in the economy. Backward linkages are defined as the purchased inputs, supplies and services, whereas forward linkages include further value-added economic activities such as preparation and processing. Amongst other things, Hussain *et al.* (2003) investigated the impact on output, value added and employment of a change in 1 000 dairy cows represent 1% of the total herd and the authors propose this as being the net change in total dairy production. A 1% change translates into a change of $5.6 million in output, 61 jobs ($655 762 in wages) and $1.3 million value added.

Kopainsky, Buser and Rieder (2005) developed an integrated model, consisting of an input/output (I/O) model and a dynamic simulation model, for analysing regional development and structural change in two regions of the Swiss mountain area. The I/O model provides a detailed description of a regional economy, whereas the purpose of the dynamic simulation model is to identify the processes and critical factors that cause the decline in employment and population in rural micro regions and to evaluate the policy implications of development strategies derived from I/O analysis. An important finding is that agriculture's role in the regional economy is very limited in that increasing final demand in agriculture, via augmented direct payments, proves only slightly effective. The effect of direct payments only has a direct effect on the agricultural sector and no additional or induced effect, implying that investing public means would be more effective in other economic sectors. According to Kopainsky, Buser and Rieder (2005), external demand is the main driving force behind regional rural development strategies that are based on local economic activities, and the diversification of the local economy implies substantial expansion of export activities in the manufacturing sector and in the private services.

Viljoen, Armour, Oberholzer, Grosskopf, Van Der Merwe and Pienaar (2006) developed and integrated multidimensional models for the sustainable management of water quantity and quality in the Orange-Vaal-River (OVR) convergence system. They developed a macro-economic-level model using a dynamic I/O model to estimate and quantify the secondary and macro-economic impacts at the regional level of the project. The calculated I/O multipliers were used to calculate the total direct, indirect and induced effect of exogenous economic inputs on jobs, income and output generated per rand of spending on various types of goods and services in the study area. According to Viljoen *et al.* (2006) the social and environmental dimensions were included at the macro-economic level of modelling, with the linkage between the regional-level model and the macro-economic model being a matrix of annual financial performance data of all or each of the farm input sectors, as well as the resulting farm financial performances for each sub-region. Economic impacts were defined as the effects on the level of economic activity in a given area, which may be viewed in terms of business output, value added, wealth, personal income, or jobs. The net economic impact is usually viewed as the expansion or contraction of an area's economy, resulting from changes in a facility, project or programme. These economic impacts, as explained by the authors, also lead to fiscal impacts, which are changes in government revenues and expenditures. The authors further explain further that the regional model builds on the results obtained from the biophysical model and the micro-economic model, with gross income, total variable cost and total gross margin as the main indicators. The I/O model used to calculate the multipliers was derived from the national accounts for the provinces relevant to the study area.

2.3.2 Social Accounting Matrix (SAM) based models

Backward and forward linkages for South Africa were derived in 1988 for both I/O and SAM models using the method proposed by Hirschman (1958) as in Townsend and McDonald (1998), and confirm the potential bias inherent to the I/O approach. The SAM results for the production accounts were found to be much larger (in some cases twice as large). The linkage estimates indicate relatively weak backward but strong forward linkages for agriculture, whereas strong forward and backward linkages were found for the food sector. In contrast the mining sector, which has traditionally been viewed as central to the RSA economy, has the lowest multipliers. The estimated the impacts of price support mechanisms in agriculture on income distribution by applying the standard SAM-Leontief to estimate accounting multipliers and the price formation and cost transmission. For purposes of calibration the 1988 South African SAM published by Central Statistical Services were used. It was found that a 6% reduction in agricultural price support resulted in a 7% decline in agricultural prices. The authors explain that the benefits of liberalisation derive primarily from improvements in resource allocation, i.e. the ability of agriculture to contribute substantially to longer-term development in South Africa will probably rest on the ability of the agricultural sector to achieve efficiency gains. They further also recommend that a CGE model oriented towards the food system will allow more detailed analysis of these issues while maintaining the advantages that derive from locating the analysis within the context of the wider economy.

In a paper with a political flavour presented at the first world congress of environmental and resource economists, Hassan (1998) evaluated the economy-wide impacts of (at the time the likely/proposed) changes in the South African water policy. The “new policy environment” places more emphasis on rectifying environmental externalities and internalising their social cost. Among the environmental resources, water is receiving special attention in recognising its evident scarcity, over-use and skewed distribution (Hassan, 1998). The main argument/ motivation behind Hassan's (1998) paper is that due to the important inter-sectoral linkages in the production and consumption of economic goods and services, the expected impacts will have far-reaching effects that go beyond sector-specific adjustments. He therefore argues that it is of the utmost importance to consider the economy-wide impacts of expected adjustments in water use and allocation in response to the changed water legislation. Despite the fact that SAM models, like I/O models, suffer from the fixed coefficient linearity structure problem, as stated by Hassan (1998), a SAM model was used to evaluate the economy-wide impacts of expected changes resulting from the new water policy. Different from the linearity structure problem of SAM models that do not allow for substitution and flexibility in supply and demand adjustments, CGE models are capable of accommodating such flexibility and therefore better model nominal and foreign sectors (Hassan, 1998). However, he notes that CGE models are very demanding in terms of data and parameter specifications. In order to solve water policy simulations, the water subsidy transfer was left exogenous to the model to induce the shocks. Two scenarios were evaluated – one where no substitution in supply was allowed and another where substitution was indeed allowed. The overall impact of the scenario with no substitution was to affect the overall output with less than 1%, whereas in the substitution case a 1% increase in total output was recorded.

The water policy bill recently (DWAF, 2004) passed through parliament introduces fundamental changes compared to the previous way in which water rights were defined and the way in which water was priced and allocated. Such policy changes are bound to cause major adjustments in the present patterns of water use and allocation. Hassan (1998) therefore analysed the economy-wide impacts of the likely policy changes. By means of a Social Accounting Matrix (SAM) framework he studied the nature and possible direction of resulting shifts in affected economic sectors and activities.

McDonald and Punt (2002) used a mixed multiplier SAM model calibrated to the SM3 SAM developed by Eckert *et al.* (1997a) to estimate some implications of trade liberalisation within a supply constraint environment. McDonald and Punt (2004) estimated the impact of the basic income grant introduced, fuel price changes and increased export demand by means of a SAM-Leontief analysis based on the Western Cape SAM compiled by McDonald and Punt (2001).

2.3.3 Applied Computable General Equilibrium (CGE) models

2.3.3.1 Static CGE models

Kilkenny and Robinson (1990) state that although the agricultural sector forms a relatively small part of the total US economy, changes in US agricultural policies may have significant economy-wide impacts. They explain further that the nature of these impacts will depend on the degree of factor mobility and disposition of the saved farm programme expenditures. Despite being a relatively small sector, Kilkenny and Robinson (1990) point out that government programmes targeted at agriculture constitute a large fraction of government spending and argue that substantial budgetary savings can be achieved with the liberalisation of agriculture. Three arguments listed in favour of agricultural liberalisation by Kilkenny and Robinson (1990) are the following:

- Removing distortions should allow for more efficient economy-wide allocations of resources and hence GNP growth.
- When less-efficient producers in other countries are no longer protected, world market prices should strengthen.
- Farm price increases due to liberalisation should make farm price support programmes unnecessary.

By applying a 10-sector CGE model under various factor mobility and macro-economic closure assumptions, Kilkenny and Robinson (1990) show that the magnitude of economy-wide gains from liberalisation (both unilateral and multilateral in nature) depends critically on assumptions about factor mobility and macro-economic closures. From the empirical results, for example, they show that the inter-sectoral links are large in that almost 40% of the changes in total sectoral income occur in the non-farm sector. In their concluding remarks Kilkenny and

Robinson (1990) state that the combination of inter-sectoral linkages and macro-economic feedback makes the use of CGE models imperative in evaluating the impact of changes in agricultural policy.

Closer to South Africa, Chitiga and Mabugu (2005) applied a combination of standard, social accounting, matrix-based CGE model and household micro data to Zimbabwean data prior to 2000. A top-down CGE approach was applied in this analysis in the sense that simulation changes from the CGE were applied to household data after which poverty was analysed. The CGE model used to simulate across-the-board removal of tariffs is based on the IFPRI standard model. According to Chitiga and Mabugu (2005) their analysis was largely based on a 'viable' Zimbabwe of the late 1990s, and no attempt was made to benchmark the model to the years following 2000. As a result of this liberalisation, import prices of food manufacturing declined by 7.7%, whereas imports of food agricultural commodities declined by 16.23%. In terms of poverty, Chitiga and Mabugu (2005) found the popular cliché – the rich get richer while the poor get poorer – to be true in this analysis of Zimbabwe.

In a systematic comparative assessment Capros *et al.* (1990) designed two small-scale models (CGE and ME) and estimated them on a common database (Greek national accounts from 1965 to 1985) in order to asses their respective simulation properties. The specification of the CGE model follows the World Bank tradition, but differs in the sense that equations are estimated econometrically and the calibration of the model is therefore reached by the use of adjustment variables. In the case of the ME model, equilibrium is obtained via quantity rather than price adjustments, which originates from the rejection of the Walrasian competitive equilibrium and a following of the view expressed by Keynes in the General Theory (Capros *et al.,* 1990). In short, Capros *et al.* (1990) explain that demand determines total production, which in turn determines the labour quantity demanded. Labour supply is determined by households, but employment is the minimum of supply and demand. The labour market is therefore quantity cleared and not cleared by price adjustments, as it would be in the GE framework. Capros *et al.* (1990) explain further that since a demand-driven economy is in question, underutilisation of production capacities may occur. The three groups of simulations analysed are development, tax policy and foreign trade aspects, and Capros *et al.* (1990) summarised the results as follow:

a) The differences in the properties of the two models can mainly be attributed to the mechanisms of supply and demand adjustments, where the ME model is based on quantity adjustments and the CGE applies price adjustments leading to both production and demand change. Secondly, the ME model does not satisfy Walras's law by allowing for disequilibria in the current account and the public deficit, whereas the CGE model is closed with respect to both domestic and foreign money flows. Thirdly, the price adjustments of the labour market in the CGE model generate more flexibility in employment results.

b) The normative (what should/ought to be) power for policy recommendations of the CGE model provides welfare-measurable results with unaltered market equilibrium. The ME model in turn has a forecasting ability especially into short-term disequilibria pressures/shocks.

c) Capros *et al.* (1990) recommend further the combined application of CGE and ME models to more effectively support policy issues.

As part of her doctoral thesis, Mukherjee (1996) used a CGE model for the Olifants River catchments in the former Transvaal Province of South Africa to investigate three main research questions: Firstly, how should the remaining available and existing water supplies be reallocated among alternative uses both productive (in economic sectors such as agriculture, mining, industry and tourism) and consumptive (both for human and ecological use)? Secondly, what should the new rules governing water use be? Thirdly, what will be the main criteria guiding the formulation of these new water rules? In order to answer these research questions, the following five hypotheses were tested by Mukherjee (1996):

a) Water as factor input will be allocated away from commercial large-scale agriculture to other sectors. This was found only to be partly true, due to the relatively low water-land coefficient; the more water-intensive sectors (like horticulture) reduce their water demand. The hypothesis is therefore true for the high-value producing sectors like manufacturing.

b) Within the agricultural sector, even without preferential policies, water will be allocated away from large-scale commercial farms and allocated to small-scale farms. This hypothesis, similar to the previous one, is again only partly true for the same reasons.

c) The hypothesis that sectoral employment will shift in accordance with water allocations, away from agriculture to other sectors that use water more productively, was rejected because it assumes that agriculture is more water intensive than other non-agricultural sectors.

d) Household incomes for poorer households will increase. Due to the specification of the CGE model, which is not well suited to examine this hypothesis because it assumes full factor employment, changes to household incomes and other aggregate variables are small.

e) Agriculture will be the overall loser in the regional economy, but given the social and financial gains achieved in the other economic sectors, regional gross domestic product (GDP) will not be seriously affected. This hypothesis was found to be true given the assumptions, since agriculture is the largest consumer of water. When water therefore becomes more expensive, output in the agricultural sector falls. However, GDP was found to be relatively unaffected, mainly because of the full employment specification of the water CGE.

Kilkenny and Schluter (1993) point out significant changes in public support programmes for agriculture in the United States. According to them, direct income transfers increased from $1.2 billion in 1982 to $13.3 billion in 1986, and the support to agricultural research and education remained constant at $1 billion for the same period. Given this, Kilkenny and Schluter (1993) comparatively analysed the impacts of these two types of support programmes. They traced the costs and benefits of the productivity improvements and farm income transfers through input/output and income/expenditure links using a CGE model highlighting rural/urban and farm/non-farm interdependencies. The rural/urban (R/U) CGE model used aggregated the entire economy into urban (metropolitan) and rural (non-metropolitan) market areas. Applying this R/U CGE model Kilkenny and Schluter (1993) found that a dollar spent on agricultural research and extension over the period mentioned above resulted in a 2.26% annual total factor productivity growth and stimulated a $0.9 net additional real economic activity economy wide. In terms of direct income transfers, $1 stimulated only $0.1 of rural net additional real economic activity, where it actually cost the whole economy an additional $0.12 real output foregone for every $1 transferred over the five-year period under investigation.

Calibrated to the 1988 SAM from the Central Statistical Services, which was adjusted with entropy procedures, McDonald and Kirsten (1999) applied a CGE model to analyse the impacts of a drop in the world price of gold and increases in the world price of agricultural commodities. They explain from their findings in the model that the effects of changes in world markets on South African agriculture are complex and difficult to predict using partial equilibrium models. More specifically, McDonald and Kirsten (1999) show that the returns to different classifications of labour diverge substantially, and hence so do the implications for different household groups, which further highlights the potential importance of income distribution effects consequent upon trade policy changes. According to McDonald and Kirsten (1999) the most notable feature among the impacts for the agricultural sector is the asymmetry of the responses, i.e. output levels respond more strongly to increases in prices than decreases, as do export volumes and producer prices. They ascribe the asymmetry results basically to the fixed supply of land, and the presumption that there are no competing uses for agricultural land. Their results show that when prices rise, farmers respond by expanding their use of intermediate inputs, labour and capital such that the capacity constraint imposed by land supply can be relaxed (McDonald and Kirsten, 1999).

Two working CGE models for the South African economy – one an orthodox, neoclassical, Computable General Equilibrium model in which savings drive investment, and the other a more structuralist and eclectic model with an independent investment function – are compared by Gibson and Van Seventer (2000a). Calibrated to the same SAM/database and confronted with identical simulations, they found the neoclassical model to fully support the principal of the "Washington Consensus" while the structuralist model requires far more heterodox policies to avoid slow growth or high inflation. Gibson and Van Seventer (2000a) explain that the neoclassical model is exceptionally well suited to the policy recommendations of the neo-liberal agenda, which closely follows the tenets of the Washington Consensus, i.e. that the efficient allocation of resources (and presumably the fastest rate of growth) requires an outward orientation, small government, a competitive exchange rate, as well as low real wages.

Thurlow and Van Seventer (2002) state that since the beginning of the 1990s a considerable increase in the use of CGE models was seen in South Africa. In explaining this, Naude and Brixen (1993), for example, used a rigid multi-sector modelling template developed by the World Bank to simulate the impact of an increase in government expenditure, export demand and world price, and a lowering of import tariffs under various closure rules (Thurlow and Van Seventer, 2002). Several large-scale multi-sectoral CGE models of the South African economy were developed by, amongst others, the Industrial Development Corporation, the World Bank/OECD, and the Development Bank of South Africa (Thurlow and Van Seventer, 2002).

Thurlow (2002) assesses the economy-wide impact of implementing and financing a universal or basic income grant in South Africa by analysing the various suggested financing scenarios in a comparative way by means of a CGE model (see Thurlow and Van Seventer (2002) for a more detailed description of the model) calibrated to a 1998 SAM for South Africa. The results indicate that the required changes in direct and indirect tax rates needed to finance the grant, without increasing the government deficit, are substantially higher than currently predicted. Furthermore, Thurlow (2002) also found that the alternative of reducing government recurrent expenditure to finance the BIG will undoubtedly undermine other government policy objectives. It is shown that the impact of the grant on economic growth is found to hinge on its ability to enhance factor productivity. He goes on to explain that the successful addressing of poverty in South Africa depends on the ability of policymakers to construct sustainable and appropriately targeted interventions. According to Thurlow (2002), while the basic income grant appears to overcome the problem of identifying the poor, the decision of whether South Africa can become Africa's first welfare state might not necessarily be determined by a universal grant's ability to alleviate poverty, but rather by macro-economic and financial considerations.

According to Van Schoor and Burrows (2003) CGE modelling is in the process of becoming a standard tool for policy analysis in South Africa. By incorporating imperfect competition and returns to scale into the standard IFPRI model, Van Schoor and Burrows (2003) reckon that the model firstly becomes more realistic and secondly allows completely new applications. Calibrated to the 1998 SAM constructed by Thurlow and Van Seventer (2002), Van Schoor and Burrows (2003) used the modified CGE mode to run two experiments, one being a unilateral free-trade simulation and the other an imperfect competition simulation. Van Schoor and Burrows (2003) found gains from trade to be around 1% higher in GDP terms compared to the model without returns to scale and perfect competition. In addition, they also found higher welfare gains when firms are allowed to enter and exit sectors in response to changes in the availability of economic profits.

With wage subsidies being proposed as an incentive for firms to employ more semiskilled and unskilled workers, Pauw (2003) analysed the outcomes of various wage subsidy experiments using a CGE model. According to Pauw (2003) multi-sector models like CGEs are useful for evaluating the impact of policy tools that can have economy-wide effects. Despite the fact that the cost of such subsidies can be substantial, the simulations analysed suggest that employment can be raised quite significantly with important benefits especially for poor households. Pauw (2003) further argues that the benefit of increased employment can justify the cost, by showing that although the negative indirect effects of raising funds for the scheme counteract the positive impact of an employment subsidy scheme, the net overall benefits are positive. The results revealed that all modelled household groups increase their income, while all industries are able to employ more workers than before.

Gibson (2003) explains that the Armington elasticity forms an essential component of modelling the effects of international trade policy. Furthermore, applied partial and general equilibrium models employed to examine trade policy are almost all sensitive to trade elasticities. A key relationship for model analysis is the degree of substitution between imported and domestically produced goods as the relative prices of those two goods change, i.e. the Armington elasticity. Indeed, the Armington elasticity is a key parameter determining the quantitative, and in some cases qualitative, results used by policymakers. With this being the motivation, Gibson (2003) aimed to provide a comprehensive and disaggregated set of Armington elasticity estimates for South Africa. Gibson (2003) derived short-run estimates for 32 industries and only 3 long-run estimates due to data constraints and limitations. Unfortunately, the primary industries of Agriculture, Forestry and Fishing are aggregated and therefore treated together as one sector with a short-run estimate of 1.273.

Thurlow (2003) extends the standard IFPRI static model into a recursive dynamic model. While the comparative static model (standard IFRPI) presents an overview of different closures relevant to the South African economy, the dynamic model can be adopted to analyse issues that will impact on agriculture, e.g. investment in rural infrastructure, the impact of AIDS, etc.

Anderson (2004) empirically analysed the potential economic effects of adopting genetically modified (GM) crops in Sub-Saharan Africa (SSA) by using the Global Trade Analysis Project (GTAP) model. The GTAP model is a global economy-wide CGE model describing both the vertical and horizontal linkages between all product markets both within the model's individual countries and regions, as well as between countries and regions via their bilateral trade flows. In the simulations, Anderson (2004) used a standard neoclassical GTAP closure, which is characterised by perfect competition in all markets, flexible exchange rates, and fixed endowments of labour, capital, land and natural resources. The simulations used involve productivity shocks of 7.5% in coarse grain, 6% for oilseeds, and 5% for wheat and rice. From the analysis done, Anderson (2004) found positive results from the selected scenarios in the sense that the GDP of SSA may increase by around 0.12% provided that all countries adopt first-generation GM varieties of major grains and oilseeds. However, Anderson (2004) states that this figure might underestimate the potential of GM technology for several reasons, which falls beyond the scope of this document.

Letsoala, Blignaut, De Wet, De Wit, Hess, Tol and Van Heerden (2007) investigated the validity of a variety of policy options that will ensure more efficient water allocation and therefore lower the use of water and have a positive impact on poverty alleviation. In order to achieve their goal, Letsoala *et al.* (2007) applied a CGE model to analyse the double-dividend hypothesis of water charges in South Africa. According to them, three of the major problems currently being experienced in South Africa are water scarcity, poverty, and unequal income distribution. One of the aims of the proposed changes in the water policy is to reduce water use by levying charges. Less water scarcity is therefore considered the first dividend from levying such a water charge and in addition revenues from these charges could be reinvested into the economy to stimulate economic growth and therefore provide the second dividend. Various authors, including Goulder, Parry and Burtraw (1997) and Letsoala *et al.* (2007) warn that such a result requires careful policy design, and if done correctly a possible third dividend, i.e. change in income distribution, might also be achieved. In their study Letsoala *et al.* (2007) further analyse the proposal of the South African government to reduce water consumption by introducing water resource management charges.

The cost and benefits of these additional water charges to the South African economy are analysed in a CGE framework. As mentioned, the emphasis in this study falls on poverty reduction through recycling the water charges revenue into higher real income to the poor. Six scenarios in total were investigated, three of which analysed the effect of a surcharge of 10c per m^3 water used by the forestry, irrigated agriculture and mining industries respectively. The remaining three simulations involved the recycling side, investigating the decrease in the overall level of direct taxation on capital and labour, a sales tax on household consumption, as well as a decrease in the sales tax rate on food to households. Amongst their findings, the one most applicable to this study is the effect of water charges on irrigated agriculture. Extra water charges on irrigated agriculture obviously increase the cost of field and horticultural production. Field and horticultural production comprise a large portion of agricultural commodities, and an increase in their prices directly affects the prices of industries purchasing them as intermediate inputs.

The four largest users of agricultural goods are food, other manufacturing, petroleum and textiles – all important to poor households. Letsoala *et al.* (2007) therefore found that the only recycling scheme that is able to offset the decrease in consumption due to water charges on agriculture is a decrease in the food tax rate. Food is the most important consumer good for poor households, and it is to be expected that cheaper food would dominate the tax on an industry only indirectly linked to poor households. Letsoala *et al.* (2007) concluded, however, that it seems possible that an additional water charge on irrigated field crops and in conjunction with a water charge on some aspects of the mining sector stands the greatest chance of yielding dividends in terms of all three pillars of sustainability, *viz.* the environment (planet), the economy (profit) and society (people). They also noted, however, that more detailed analysis with more specific charges needs to be carried out to further substantiate their findings.

Thurlow and Van Seventer (2002) demonstrated the usefulness of economy-wide policy modelling by constructing and testing the Standard International Food Policy Research Institute (IFPRI) CGE calibrated to a 1998 SAM for South Africa. This model was then used to simulate the economy-wide impact of a range of hypothetical policy levers, including increased government spending, the elimination of tariff barriers, and an improvement in total factor productivity. Firstly, Thurlow and Van Seventer (2002) found expansionary fiscal policy to be growth enhancing and secondly that a complete abolition of import tariffs generates an increase in the gross domestic product. Thirdly, they also proved that an increase in total factor productivity is growth enhancing.

In order to analyse the effects of rice productivity shocks, declining world rice prices, as well as a reduction in Bangladeshi textile exports, Arndt, Dorosh, Fontana and Zohir (2002) developed a Bangladesh SAM for 1999/2000 to which they calibrated the standard IFPRI model. The simulation results show that rice productivity increases helped to reduce rural poverty in the two decades preceding the study. They furthermore show that the establishment of trading links, preventing decreases in export rice prices, can lead to income gains for both producers and consumers. In terms of knitwear, a simulated 25% decrease in textile exports leads to a 6% decrease in wage payments to unskilled female labour in non-agricultural sectors and a 0.5 to 1% decline in the real incomes of urban poor households. Arndt and Lewis (2002) concluded that international trade offers the potential to prevent a decline in the real prices of rice given a production/productivity increase.

To be effective in terms of policy analysis, Devarajan and Robinson (2002b) explain that an economist must provide relevant, transparent and timely results. They explain that CGE models are very useful whenever policy changes affect a large share of economic activity or when it is important to consider changes in the sectoral structure of output, trade, demand, employment and/or prices. Despite the fact that CGE models used in policy work vary widely in size, complexity and domain of applicability, Devarajan and Robinson (2002b) state that these models are essentially designed to analyse the links between policy choices and economic outcomes. It is therefore important that the questions that drive the policy debate also steer the models.

What can probably be seen as one of the largest research efforts to focus on CGE modelling is the Provincial Decision-making Enabling Project (PROVIDE) with the National and Provincial Departments of Agriculture as stakeholders and funders of the project. The main aim of the project is the development of a series of databases (in SAM format) for use in CGE models. A national SAM plus four regional SAMs are available for the 2000 basis year. The regional SAMs are compiled with disaggregated detail for agricultural activities for groups of provinces, i.e. Western Cape and Northern Cape; Eastern Cape and KwaZulu-Natal; Gauteng, Free State and North-West; and Limpopo and Mpumalanga. A generic CGE model designed for *ex ante* evaluations of policy scenarios was also developed. This CGE model, which is calibrated to the SAM described above, was then applied to a series of case studies addressing contemporary policy concerns in the regions of South Africa. Some of the topics addressed for different regions in the case studies include trade liberalisation, welfare impacts of national and international agricultural efficiency gains, oil price shocks, import tariff changes, targeted transfers to households, increase excise duties, as well as property rates on agricultural land.

McDonald and Punt (2005) provide an overview of general equilibrium models analysing agricultural issues in South African since the mid 1990's. According to McDonald and Punt (2005) the modelling and computing techniques have vastly improve during the past decade, partly on an ongoing basis to refine existing models but also partly in an attempt to extend the modelling framework to make provision for issues that cannot be sufficiently captured in the standard comparative static models. In terms of data requirements, McDonald and Punt (2005) explain that improvements in data for the construction of national-level SAMs are clear from Statistics South Africa (StatsSA). However, provincial data requirements are not sufficiently met, posing major challenges for provincial and regional modelling. More specifically, the absence of supply-side information in the initial I/O tables produced by StatsSA led to SAMs being produced for use in CGE modelling, of which accounts must have been reconciled/altered by individual users before calibration could take place. As a result, a number of unofficial SAMs materialised over time from different sources, mainly inspired by the needs of various GE models (McDonald and Punt, 2005), for example:

- World Bank – Devarajan and Van der Mensbrugghe (2000), Arndt *et al.* (2000), and Go, Kearney, Robinson, Thierfelder (2004)
- IFPRI – Thurlow and Van Seventer (2002)
- Chant, McDonald and Punt (2001)
- Conningarth Consultants
- Development Bank of Southern Africa (DBSA) – Gibson and Van Seventer (1996)

Despite the fact that these databases are incomplete in most instances, McDonald and Punt (2005) argue that there has been an overinvestment in modelling the Southern African economy and an underinvestment in the development of the databases underpinning these models.

McDonald and Punt (2005) further note that provincial-level CGE applications exist for the Western Cape, where a CGE model was developed for that province by McDonald (2002). This model was used by McDonald *et al*. (2001) to analyse trade liberalisation effects, by McDonald and Punt (2003b) to investigate the implications of a basic income grant in the Western Cape, and by McDonald and Punt (2003c) to asses some welfare implications of a land tax in the Western Cape Province of South Africa. Different from I/O techniques that were originally developed to analyse production linkages in the economy, SAM-based CGE models focus more on analysing the impact of policy options on poverty and income redistribution (McDonald and Punt, 2005). According to McDonald and Punt (2005) recent developments of CGE models (and databases) are for adaptation to analyse environmental issues such as the impact of CO_2 emissions, Kyoto Protocol scenarios, water-related issues, soil degradation, etc. Other issues that can be addressed in a CGE framework include land reform, environmental issues, trade negotiations, production linkages, price linkages, impact on employment and poverty, welfare, taxation, and investment (McDonald and Punt, 2005).

In a study forming part of IFPRI's multi-country research initiative known as Macro-economic Reforms and Regional Integration in Southern Africa (MERRISA) Tarp, Arndt, Jensen, Robinson and Heltberg (2002) developed a SAM for Mozambique for the 1995 base year. The main aim of the broader study is to demonstrate that sophisticated analytical tools can be of significant value, even in “data-poor” situations. This SAM developed was firstly used to highlight the importance of agricultural development through a series of traditional SAM-based multiplier analyses. These analyses show that agriculture has large sectoral multiplier effects relative to non-agricultural industries and that applying scarce capital to agriculture is generally more effective than applying it to industry and services. Secondly, the SAM also forms the basis for calibrating a static Computable General Equilibrium (CGE) model, capable of capturing many key aspects of the performance of the Mozambican economy in the post-war period. The CGE model is used in a series of concrete analyses focusing on the impact and design of economic policy. Among the challenges addressed by Tarp *et al.* (2002) are:

- aid dependency,
- price incentives facing the agriculture sector,
- agricultural technology and marketing margins,
- risk-reducing behaviour and gender roles in agricultural production, and
- food aid distribution.

From the empirical application on the Mozambican economy, Tarp *et al.* (2002) arrived at a number of insights, including the following:

- Priority should be given to the simultaneous improvement in agricultural productivity, especially in small-scale farming, and in marketing infrastructure to reduce marketing costs.
- Technological change in cassava, for example, appears to be a particularly strong lever for increasing female and overall household welfare.
- Results from the analysis suggest a strong potential for agricultural-led development with attractive distributional implications, provided adequate policy measures are taken.

- The negative effects of unavoidable natural calamities can be minimised if appropriate schemes for distributing food aid are put in place.

Tarp *et al.* (2002) caution, however, that while the CGE model is capable of providing many policy-relevant insights, it cannot be relied upon as a guide in budgetary planning within the medium-term framework.

According to Hess (2005) an important task for applied and agricultural economists is the provision of quantitative assessments of, amongst others, the regional and national distribution of potential gains and losses from agricultural and other market liberalisation to policymakers, as well as the concerned public. CGE models are considered state of the art when it comes to assessing international trade policy changes, with Hess (2005) stating that they sometimes result in direct entry into trade negotiations.

2.3.3.2 Dynamic CGE models

Gibson and Van Seventer (1996) compared a savings-based growth strategy with a more heterodox approach in which public spending lowers the marginal capital-output ratio in various sectors. From simulations run with a multi-sectoral dynamic Computable General Equilibrium model, they confirmed relative full-capacity utilisation to foster economic growth. According to Gibson and Van Seventer (1996), a coherent policy package that will meet the needs of a complex, interrelated and fragile economy is required to bring about the required growth in output and employment.

Gibson and Van Seventer (1997) numerically estimate the relationship between green trade restrictions, macro-economic performance and environmental quality in South Africa by means of multi-sectoral dynamic CGE model. For all three simulations analysed, a quadratic extensive environmental loss function is evaluated, which assigns weights to the emission of greenhouse gases and water contaminants. The three scenarios that were evaluated are the following: Firstly, the response to greenhouse gases and water contaminants; secondly, restrictions on foreign imports of South African mining products, particularly coal; and thirdly, restrictions on non-primary or manufactured exports due to consumption externalities generated by the energy-intense methods of producing them. From these simulations, Gibson and Van Seventer (1997) confirm that the interaction between the macro economy and the environment is a complex and subtle process due to its wide-ranging, highly diverse and uncertain nature. Despite the two caveats listed, Gibson and Van Seventer (1997) conclude that the thread of green trade restrictions on the macro economy cannot be taken lightly, in the sense that the cost of green trade restrictions to South Africa will be very high compared to the costs of cleanup. Their simulations further show that the differences in the production of greenhouse gases, i.e. global warming, will be almost negligible. Gibson and Van Seventer (1997) therefore make it clear from their analysis that South Africa should do everything within its power to minimise the risk of green trade restrictions being implemented, including cleaning up, before these restrictions become a real threat. In concluding towards a growth strategy based on the simulated results, Gibson and Van Seventer (1997) firstly remark that contractionary fiscal policy will counteract the recovery in private sector investment. Given a reduction in the public sector borrowing requirement (PSBR), income, output and employment are likely to fall *ceteris paribus*. Secondly, they empirically found that progress towards the goal of increasing public sector investment is possible, given a reduction in government employment.

As in many other developing countries, higher wages in South Africa are believed to reduce employment (Gibson and Van Seventer, 2000b). Similar to the dynamic CGE models used in other studies, they used such a model to scrutinise the employment effects of nominal wage increases. It was found that the employment effects of nominal wage increases depend on induced monetary and fiscal policy when there is monetary policy dominance. They further found that while wage-led growth is inefficient, increasing the wages of unskilled workers can improve the distribution of income when the induced changes are neutralised. There is thus a growth-equity trade-off in the model, which is much less severe when wage increases are targeted at unskilled labour.

Kearney (2006) analysed the impact of various water tax scenarios in South Africa by means of a dynamic CGE model calibrated to a SAM for 2000 developed by Quantec. The CGE model used is based on the model developed by Thurlow (2003), which is an extension of the static model developed by Löfgren *et al.* (2002) that follows the neoclassical-structuralist modelling tradition. According to Kearney (2006) the Quantec SAM is based on the 2000 national accounting figures, with the 2000 supply-and-use tables forming the core of this SAM. In short, the SAM includes 43 commodities and industries, 4 production factors, and 14 households. Kearney (2006) further explains that water is captured as both a commodity and an activity in the 2000 SAM and that, according to the 2000 SAM, the water industry contributes 1.9 percent to GDP and 0.06 percent to total employment. The water industry is relatively capital intensive (67.2 percent of total factor use), and employs relatively more high-skilled labour (22.8 percent) compared to semiskilled (6.3 percent) and unskilled labour (3.7 percent). Water is sold mostly to industries, with 82.8 percent of total water supply used for intermediate use, whilst only 17.2 percent is used by households (Kearney, 2006). Three sets of scenarios were analysed by Kearney (2006): Firstly, a comparison was drawn between the short- and long-run impact of a 20% increase in the tax on water. Secondly, the impact of 20, 30, 40 and 50 percent increases in the tax rate were investigated, with the 50% increase in the tax rate lifting the effective rate from 2.3% to 3.4% and therefore still representing a relatively minor increase in the overall tax burden. With the final set of scenarios Kearney (2006) investigated the impact of technology improvements on the use of water, with the presumption that the increase in the water tax would force producers to become more efficient (10 percent from 2006 onwards), as producers cannot (easily) substitute water. Resulting from the analysis, Kearney (2006) summarised that the introduction of the tax would lead to an increase in the price of water, resulting in a decline in the demand for water by both households and producers. This in turn would have a negative impact on employment, income, consumption, savings and economic activity within the sector. The revenue generated by the tax, however, would be spent on additional fixed government investment, which in turn should stimulate economic activity, employment, consumption and so forth. The final outcome would depend on the relative strength of these two opposing effects (Kearney, 2006). Results from the CGE model show that in the short run, the tax on water would have an insignificant negative impact on GDP, whereas in the long run, the GDP increases as the rise in investment offsets the decline in consumption. In terms of industry-specific results, Kearney (2006) reports that the short-run loser is the water industry itself, the hotel and accommodation industry, the downstream chemical industry, and the petroleum industry, as they use a relatively larger share of water in total intermediate use. Concerning labour employment, in the short run, Kearney (2006) reports from the model results that the employment of unskilled labour decreases, due to the negative impact of the higher tax on water consumption, which reduces output and hence the demand for low-skilled labour. The situation is reversed in the longer run as employment of unskilled labour in investment industries increases; for example, the construction industry (an investment industry) employs unskilled labour intensively (26.9 percent) and employs a relatively large share of the total employment of unskilled labour (8.1 percent). In terms of welfare, the equivalent variation results indicate that in the short run, poorer households' utility declines, while the utility of high-income households increases. The utility of high-income households is less affected, as they spend a smaller share of their income on water. Higher-income households are also the biggest savers in the economy. In the long run, the results indicate that the utility for all households declines. Poorer households are the worst off as they spend a relatively larger share of their income on water (Kearney, 2006).

Roe (2004) investigated the static and dynamic effects of global liberalisation of agricultural policies and found that total liberalisation can cause the index of world agricultural prices to rise by almost 12%. Tariffs account for more than half this increase, whereas domestic support and export subsidies are to blame for 30% and 13% respectively. Roe (2004) also ranked the main culprits, and from highest to lowest the four major countries are the EU, the US, Japan and Korea. From the static effects, Roe (2004) found that agricultural support and protection in developed countries is the major cause of low agricultural prices, and implicitly, a tax on net agricultural exports of developing countries. He also states further that reform should increase world agricultural trade, but the level of agricultural production should remain relatively unchanged. However, due to the agricultural trade patterns of African countries trading mostly with the EU and Latin American and some Asian countries trading with the US, the effects of liberalisation have differential effects on the developing world. In comparing the gains from trade reform simulated static to the dynamic models, Roe (2004) shows that the dynamic gains dominate the static gains. Specifically in the case of Sub-Saharan African countries, institutional reform could lead to more than double the per capita income over a number of years.

Diao *et al.* (2004) explain the macro-micro linkages between the economy of a region or province at large and the farm level as being bidirectional. Macro-economic policies associated with removing various trade and domestic barriers to open the economy are, for instance, top-down links affecting the irrigation sector indirectly. Water management policies at the farm-perimeter-district level, such as assignments of water rights to farmers or different ways to price irrigation water (e.g. per area, volumetric, market based) are bottom-up links that affect the irrigation sector directly. Hence, after being adopted by a large number of farmers, these water management policies have indirect effects on the economy as a whole, which in turn feed back (largely through factor markets) and affect the micro level. A more comprehensive discussion on the linkage between the micro and macro models can be found in section 2.5 of this document.

In what can be considered groundbreaking research, Roe *et al.* (2005) investigated policy interventions for improving irrigation water allocation decisions by including macro- and micro-economic considerations in a unified analytical CGE framework. Both top-down and bottom-up policy interventions of external shocks affecting the Moroccan water sector were analysed empirically. Trade reform is used as a top-down or macro-to-micro link, whereas farm water assignments together with water trading possibilities represent the bottom-up or micro-to-macro linkages. Roe *et al.* (2005) found these policies to strongly influence the productivity of water, with the indirect (general equilibrium) effects often modifying or even sometimes reversing the direct (partial equilibrium) effects. They also found that economic reforms outside of agriculture affect the productivity of water in irrigated agriculture. The impacts of the two different reforms assessed are found to be different, with trade reform having an absolute impact of a higher magnitude compared to water reform. Roe *et al.* (2005) therefore conclude that the packaging and sequencing of policy reform proves to be very important and deserves further research.

2.3.4 Other impact models

With the adoption of a simple growth model, Poonyth, Hassan, Kirsten and Calcaterra (2001) explain the effect of the agricultural sector's growth on the non-agricultural sector. Analogous to findings by previous authors, as referenced by Poonyth *et al.* (2001), including Mellor (1976), Adelman (1984) and DeJanvry (1984), a productivity differential between the agricultural and non-agricultural sector was found by Poonyth *et al.* (2001) by using data for the period 1973 to 1997. Linking up to development economic theory, i.e. industrialisation depends on agricultural improvements, Poonyth *et al.* (2001) explain that in the South African case the underlying argument is that there are significant productive and institutional links between agriculture and the rest of the economy. Agricultural growth produces strong demand and supply incentives that “cultivate” industrial expansion, and therefore given a stagnant agricultural sector, a country is unlikely to experience industrial development. For successful development Poonyth *et al.* (2001)

therefore recommend an "agricultural-led" growth strategy with policies directed at facilitating agricultural growth.

2.4 RISK AND THE AGRICULTURAL ECONOMY OF THE NCP

Louw *et al.* (2007) developed, as the first part of a WRC funded project, a regional DLP model to quantify the regional impact of market risk on irrigation schemes in the NCP. The NCP was identified as an appropriate case study area since irrigation agriculture makes such a substantial contribution to the provincial economy. In the next two sub-sections, the micro economic modelling framework and corresponding scenario results are discussed respectively.

2.4.1 Regional economic modelling framework applied

According to Louw *et al. (2007)* the marketing environment has become more risky and more volatile, both in terms of operational and strategic risks and therefore calls for external assistance/tools that producers and other decision makers should use in developing risk management strategies. Louw *et al* (2007) further explain that in order for producers to become more effective managers and thereby enable them to continue to be competitive in the global marketplace, it is important for them to know what tools are available, the advantages and disadvantages of each tool, and how they can be used individually or together to manage risk.

Risk management in agriculture has become an important part of the management function for primary producers, industry bodies, and government alike. Analytical tools used as part of a framework to aid decision makers in formulating risk management strategies can be extremely useful. However, decision makers will only use these analytical tools if their value to make better decisions can be proven. Water allocation and water use efficiency is an important component of the New Water Act (1998). It is therefore of paramount importance to consider the impact of market risk on efficient water allocation and water use efficiency. Louw *et al (2007)* explains that the first step in the development of a decision-making framework is to describe the system. In this study, the system is irrigation agriculture in the Northern Cape (consisting of approximately 143 000 ha). The second step is the development of a modelling framework to enable decision makers to get a better understanding of how the system reacts to exogenous impulses (negative or positive) all with a direct or indirect link to the market risk.

The dynamic linear programming (DLP) technique which was used in this study has been extensively used in other countries, especially the USA and Europe, as well as in SA. According to Louw *et al (2007)* any attempt to simulate the farm system should at least include the objectives of the farm unit, the resources available to reach these objectives, and the alternative activities to reach them.

Louw *et al (2007)* explain that within the regional spatial modelling domain, the use of DLP has been limited in the past by computer capacity. It is only during recent years that it became both possible and practical to embed several DLP whole farm models combined into a spatial framework and to solve these models within reasonable time.

For the regional economic modelling purposes, the irrigation regions in the Northern Cape were demarcated into 7 modelling regions. A farm survey of the regions revealed major differences in farm structure and economies of scale for the North East, Middle and Western parts of the Vaal, Riet and Orange River. From the farm survey data, 22 typical farms were developed and included in the decision-making framework. A large variance between typical farms and regions in terms of farm structure, labour use per ha, and the ratio between canal abstraction and abstraction directly from the river were found by Louw *et al (2007)*. This is important in understanding the results of the models since it will determine the reaction of each typical farm to changes in parameters when scenarios are analysed. According to Louw *et al (2007)* different typical farms will react differently when the same parameters are changed because of economies of scale, farm structure, water usage, etc.

Louw *et al (2007)* explains that the typical farms are the primary production units within a sub-regional modelling framework. The sub-regional models are therefore an aggregation of typical farms and the Orange River regional model an aggregation of the sub-regional models. The models were developed in GAMS and are solved with the CPLEX algorithm. Louw *et al (2007)* further also point out that the development of both the typical farm models and the regional models provides the analytical framework to analyse alternative risk-reducing strategies. The table grape scenario analysed are used to prove the usefulness of the framework, since it contains all the elements to illustrate how a lack of marketing information can lead to sub-optimal resource allocations and further also to suggest risk-reducing practices that will ensure more effective resource (water) management and utilization. For a more detailed description of the micro economic models used, readers are referred to Louw *et al (2007).*

2.4.2 Results of the regional economic scenarios

Louw *et al* (2007) considered a decline in the table grape price as scenario, and motivate it to be extremely useful as case study since it contains all the elements to illustrate how the lack of marketing information can lead to sub-optimal resource allocations. Suggestions on risk-reducing practices and more effective management practices were then developed based on these results. In the case of the farm level model, a total of 16 variants of the table grape scenario were analysed, ranging from a 10% to 35% reduction in the producer price of table grapes, variations in land use patterns as well as crop production patterns. With the regional model, 15 variants were analysed based on the table grape scenario, ranging between a 10% to

25% reduction in the price of table grapes, variations in long term crop areas as well as the allowance of water trade.

Some of the most relevant results and therfore also findings of the farm level model include:

- A 20% decrease in the price of table grapes reduced the return on capital investment from 37.4% in the base to around 18.5% (reduction of more than 50% in Net Farm Income). It was further also pointed out that a reduction in the table grape price of around 40% is infeasible (farmers go bankrupt). From a risk management point of view, it is therefore important for farmers to get involved on the marketing side of the supply chain. This is not only true for table grape farmers but for all crops as a powerful tool to manage marketing risks.
- The results also clearly indicate that a more diverse farming structure is a key strategy to reduce marketing risks, in the sense that the optimum farm structure after a reduction in the table grape price is different than the initial observed farm structure.
- An extremely difficult result of marketing risks to manage, is its impact on land values. Since 2002, the observed market value of land was reduced by more than 50%. Farms sold in excess of R150 000 per ha were auctioned for less than R70 000 per ha. The impact on financing should be obvious since financiers react to the observed value of land because of the reduction in their security value. Farms that were solvent became insolvent over a short period just because of a re-valuation of the property.
- When the price of table grapes is reduced by 20% and it is not possible to make structural changes, the total net output of the Northern Cape is reduced by R6.33 billion over 20 years or R316.5 million per annum (this is the cumulative effect of a reduction of 20% in the price of table grapes over 20 years). This figure gives an indication of the cost of “not knowing”.
- The analysis also shows that there is a substantial increase in land and water use in the Vaalharts region when water trade is possible. Land use increases from 119% to 138% when the calibration restrictions are released, given the possibility of water trade. Overall water use efficiency increases since water can relocate from water surplus regions to water shortage regions.

In the case of the regional model, to get some insight on the impact of water tariffs, several scenarios with trade, without trade and crop prices reductions were analysed. These scenarios fall into the category of the impact of increasing input cost on farm profitability and also on the ability to absorb market risks. Louw *et al (2007)* concluded the following from the analysis:

- Water tariff increases in the order of 100-200% are not uncommon in the Northern Cape since 2002. Especially the tariff for direct abstraction from the river increased significantly.
- Water costs as a percentage of total production cost vary from less than 1% for most long-term crops to between 5-12% for short-term crops. It is therefore obvious that

increased production costs will impact more negatively on farm profitability in the regions where the majority of crops are short-term.

- The results indicate that without water trade, the impact of a 150% increase in water tariffs results in a reduction in the total value (objective function value) of irrigation farming by about 3.4%. This amounts to a cumulative effect of R 290 million in present value terms over the 20-year planning horizon.
- When the table grape price is reduced by 20% and grain prices by 10%, it is indicated that grain farmers can not absorb more than a 110% increase in water tariffs. However, at the same time, it is also pointed out that not all farms are in the same position with the impact on the regions where long-term crops are produced being insignificant.
- The total Net Farm Income is reduced by 9.9% when crop prices are reduced by 20% and water tariffs increase with 110%.
- At a water tariff increase of 250%, total water usage only declines by approximately 6.8%. This result is consistent with the results from other studies that indicated a very inelastic water demand for agricultural and more specifically for long-term irrigated crops.
- Louw *et al* (2007) further also show that when both crop prices are reduced and water tariffs are increased, water trade increases substantially, from about 6.8 million m^3 to approximately 22 million m^3. This result is important since it shows that the reduction in crop prices increases the sensitivity of farms to increasing water tariffs.

2.5 GOVERNANCE AND WATER MANAGEMENT

One of the sub-objectives set in this study includes the development of a policy framework and institutional responses on effective water management for regions where irrigation agriculture makes a major contribution to the economy. In addition it also aims to make recommendations on institutional responses that will reduce risks and improve the financial viability of the individual farmers and irrigation schemes mainly based on the regional level modelling results (see also Louw *et al* (2007)). The latter specifically focus on market and marketing risk and the responsibilities of role players on four different levels of the value chain, including: individual farm level, industry or organised agricultural level, Water User Association (WUA) as well as provincial and national government level.

In order to develop a policy framework on efficient water management, a proposal is made on an "ideal" governance and water management structure mainly following the framework provided by Sgobbi and Fraviga (2006). This proposal stipulates the roles and responsibilities, and follows a normative approach asking "what ought to be", of role players involved at the different levels in the following five sections together with corresponding sub-sections (seven thereof) in order to reach an effective water management position.

2.5.1 Effective water governance

Surely the two most important factors menacing sustainable future water use are water scarcity and water quality. Sgobbi and Fraviga (2006) explain that internationally there is a drive towards improved present water use practices, which is based on a new paradigm of natural resource governance based mainly on the sustainability concept. They further point out that an efficient and effective governance system needs to coordinate actions developed (in line with global approaches and corrective measures) which can be implemented nationally.

These global approaches, which often results from international forums, include: the Millennium Development Goals, the World Summit on Sustainable Development (including the Johannesburg Plan of Implementation), NEPAD Water and Sanitation Sector policy objectives as well as the Southern African Vision for Water, Life and the Environment in the 21^{st} Century (DWAF, 2002). Common to the goals and objectives of the international forums are basically four concepts, including: **sustainability**, **equity** (as well as access to safe and adequate clean water supply and sanitation, especially for the poor), **integrated management** (stressing the roles of Public Private Partnerships or abbreviated as PPP or P3) and finally **improved efficiency**. These four concepts figure strongly throughout the South African water law.

2.5.1.1 Sustainable governance

A critical determinant of sustainable development is individuals' attitudes towards sustainability. Sgobbi and Fraviga (2006) list six key critical principals of sustainable governance, with the first two: it being a global process with shared objectives respectively. Thirdly, a strong monitoring and reporting framework is required which can, fourthly be coordinated by national and international actions. In the fifth place, sustainable governance must be supported and approved by all social actors, inclusive of civil society and stakeholders in the decision making process. Finally, it also calls for efficient and effective dissemination and awareness raising strategies.

The integration of scientific knowledge into the policy making process is furthermore of absolute importance for sustainable governance. Form sustainable development the following can be expected (Sgobbi and Fraviga, 2006):

- Identify and formulate shared objectives for transnational issues, as well as well as participatory policy design and monitored implementation;
- Frame local intervention - local actions should take place within a global development framework, supported by institutions and individuals;
- More direct involvement of individuals in the decision making processes, with the ultimate objective of increasing their awareness and interest, and facilitating the implementation of agreed policy measures;

- Identification of new collaboration formats between government and non-governmental actors, with the aim of establishing strategic partnerships.

2.5.1.2 New vs. traditional governance

The difference between the "new" and "traditional" governance approach is that the traditional approach relies on the state authority, sectoral differentiation and command and control type of instruments, whereas the new approach are rather associated non-hierarchical decision making processes - involving both public and private stakeholders (Sgobbi and Fraviga, 2006). They further also clarify that this new governance approach is characterised by a more predominant role of PPP (i.e. co-operation and positive interactions between the state and local actors). This new governance approach is therefore rather a bottom-up (inclusive) approach compared to the top-down traditional approach.

According to Sgobbi and Fraviga (2006) a precondition for effective governance is the "full cooperation among different institutions and actors (being them local or national, government or non-government) who should act together to attain a shared objective". A further important objective, which is especially true in the case of developing economies, is the management and resolution of existing conflicts, as well as the prevention of new challenges at the local, national and global levels.

2.5.1.3 Governance in developing and developed countries

Sgobbi and Fraviga (2006) make it clear that the implementation of sustainable governance is likely to be more problematic in developing countries compared to developed countries. This is because, not only must the process include the acquisition of new knowledge and capacity building at institutional level, but it further also calls for the collection of additional data and indicators. They warn further that strong inequality and income differential, coupled with low capacity and awareness by both the population and governing bodies, may however hamper the process of implementing sustainable governance practices in developing countries. This can even be further hampered, and is therefore further complicated by:

- existing international trade barriers,
- poor state of infrastructure (transport, communication, utilities networks, etc), and
- International debts, coupled with continued population growth.

2.5.2 The need for an integrated management approach

Water is not only an essential resource for socio-economic development of nations but it also maintains the functioning of key ecosystems as well as environmental goods and services (Sgobbi and Fraviga, 2006). A major challenge with water management, as in the case of most other natural resources, is that it has traditionally been considered a “free” good to which access cannot be restricted or is very difficult to regulate.

Despite being mostly renewable, the availability of water resources rapidly deceases with overexploitation, i.e. a higher abstraction rate compared to the natural rate of replenishment. Various authors, like Gleick (2000) and Raskin, Gallopin, Gutman, Hammond and Swar (1998) as in Sgobbi and Fraviga (2006), confirmed that in publications by international organizations the increasing water scarcity problem, both in terms of quantity and quality. These authors further also elucidate that water shortages are not only absolute (i.e. physical) but also economic in the sense that the water crisis has been further aggravated by the inefficient management and allocation of the resource, degradation of available water by pollution or inappropriate sharing rules.

The factors responsible for global water shortages are interrelated and can by summarized as follows (The World Bank, 2003):

- **Demographic factors** – the growing human population, which has tripled over the last century, together with the increasing per capita demand (direct demand) for water link to improved socio-economic condition. Indirectly, the per capita demand for water is further amplified due to the increased demand for water consuming goods and services such as food and energy.
- **Economics factors** – three market failures in water management are largely to blame for the economic scarcity thereof. Firstly, sub-optimal water prices have consistently failed to reflect the true value of water. Secondly, the public good nature of some water services caused under-provision of water in some cases and the over-provision of pollution in others. Thirdly, positive externalities results for example in reduced health hazards, reduced time spent collecting water, whereas negative externalities often result from individual users not recognizing the negative impacts their water use has on other agents.
- **Climate change or variability** – impacts significantly on water management both directly (stochastic changes in water availability) and indirectly (through its impacts on water-using sectors e.g. agricultural productivity and economic output).
- **Food security** – a strong link exists between water and food security and therefore also the way water scarcity is perceived at political level.

Rogers and Hall (2003) claims that the poor integration of water resources into the economic system can often be blamed on cases of the economic scarcity of the resource, whose cause is therefore to be found in inefficient management practices. In the next subsection, a more detailed explanation (or formal definition) of Integrated Water Resource Management (IWRM) is given, followed respectively by the role information, institutions and the private sector play in the remaining three sub-sections.

The South African water law, fortunately, recognises the need for an integrated management approach of its national water resources. DWAF (2002) explicitly states that “there is increasing understanding internationally that water resources can be successfully managed only if the natural, social, economic and political environments in which water occurs and is used are taken fully into consideration”. The South African National Water Resource Strategy (NWRS), discussed in more detailed below, therefore explicitly calls for an integrated approach in water management.

2.5.2.1 Integrated Water Resource Management defined and explained

Sgobbi and Fraviga (2006) explain that IWRM as policy paradigm can be traced back to the early 90’s, when concerns for the health of key ecosystems, such as rivers, coastal areas, hydrological basins, and groundwater resources, acquired significant importance. In essence IWRM seeks to find a balance among the needs of satisfying water demands from different users while at the same time ensuring that water resources are not irreversibly depleted. The Global Water Partnership (2000) defines IWRM as a process which “promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems”.

With the main objective of IWRM being the achievement of an efficient and equitable system of distributing and managing water resources, it applies the concepts of sustainable development to the field of water planning and management, aiming at ensuring that water use is efficient, without compromising intra-generational as well as inter-generational equity. Wolf, Stahl and Macomber (2003) explain also that IWRM adopts some principles of ecological sciences in terms of system approaches and technical and analytical tools to tackle water management problems. According to them, it is within this framework that information system tools are acquiring increasing importance, both in shaping policy making processes and in providing an exchange platform to facilitate interactions among different interested parties.

From the definitions and description above, it is clear that IWRM requires the full integration of global, national and local strategies, and the devolution of decision making and implementation power to the lowest possible governance level (Sgobbi and Fraviga, 2006). The authors further call for the promotion of PPP with the objective of improving the efficiency and effectiveness of water policies. This requires the active participation of all key stakeholders in designing and implementing management policies, through negotiation processes, voluntary agreements, and partnerships.

The IWRM decision making process should happen at three governance levels, i.e: individual, operational and strategic planning. The key principles that must be considered by IWRM strategies (according to Risse (2002) include:

- Improvement of economic efficiency of water use – attempt to regulate demand and reduce water scarcity,
- Balance between efficiency and equity – guaranteed unbiased access to safe water in adequate quantities for all, and
- Ecological and environmental sustainability of water use strategies, aiming to preserve equal development opportunities for future generations.

Sgobbi and Fraviga (2006) further explain that such a complex decision making process can be supported by the use of information and communication tools and system analysis, coupled with accurate monitoring strategies and instruments. They further also point out that IWRM also entails the explicit consideration of risk factors and the mitigation thereof, with the aim of balancing out expected benefits of actions and the uncertainties that still surround them.

2.5.2.2 The role of Information

Information acquisition and dissemination are critical components of IWRM, which can facilitate conflict management on different water needs and availabilities. Sgobbi and Fraviga (2006) explain that monitoring and assessment indicators, covering social, economic and environmental aspects of water management, are tools available for information dissemination both for scientific and popular communications. The purpose of these indicators can be threefold: Firstly they provide the building blocks on which success or failures of direct measures can be assessed. Secondly they also make up the conceptual framework for organizing and simplifying otherwise complex systems and thirdly, they help project conceptual analysis and future scenarios.

2.5.2.3 The role of Institutions

The institutional arrangement, both at national and international level, within which IWRM operate will influence to a large extend the success thereof. Sgobbi and Fraviga (2006) explain also that the balance of power between central government and powerful municipalities and/or private stakeholders significantly influences the final outcome of the process. Furthermore, ethical and political considerations play a crucial role in shaping government’s approach to water resources.

According to Sgobbi and Fraviga (2006) experience showed that a good practice is to have a single institution with a mandate of undertaking strategic planning, development and management strategies for water resources. This institution should then provide a clear framework and national guiding principals to implementing agencies. Due to the political nature of water, it is advisable to make this body independent of, but reporting to the national government, in order to ensure its neutrality with respect to the interests of different water users and needs.

Sgobbi and Fraviga (2006) propose that water resource allocation shouldn't continue along the lines adopted in the past, but rather be based on the economic value of water under different uses. Allocation strategies then need to include conflict management tools in case of emergency water scarcity situations, through for instance consensus building.

According to Herrera, Van Huylenbroeck and Espinel (2005) procuring a more active participation of users in the governance of irrigation is a sound institutional arrangement that has proved successful in many countries if some conditions are met. These conditions are basically related to establishing better farmer's backward linkages with input supply systems (financing included), as well as forward-linkages with output marketing systems. Herrera *et al* (2005) further also explain that these linkages are outside the boundaries of irrigation institutions, which implies that a broader view of institutional change is therefore necessary. This implies that it is not enough to have a supportive formal institutional environment for water issues, secure water rights, local management capacity building, and an enabling process to facilitate management transfer, which has been the approach proposed by donors agencies and development organizations.

2.5.2.4 The role of the Private sector

As in many other countries, the public sector in the Mediterranean countries proved to be inefficient in terms of delivering water services. Sgobbi and Fraviga (2006) explain that this inefficiencies lead to large water losses coupled with financial non-sustainability due to pricing systems not providing the necessary incentive to water users for efficient management of the resource. In addition, poorly managed infrastructure and inefficient investments in new infrastructures are also often observed.

In order to improve efficiency mentioned in the previous paragraph, many authors (including: Dinar, 1998; Borzel, Guttenbrunner and Seper, 2005 as well as European Commission, 2000) propose a more active and important private sector involvement in managing water resources. Further possible advantages from privatization of water services include: technological improvements as well as better managerial capacity.

Changes in water tariff structures are however a possible negative social and economic impact that may harm the poor or business minded water companies may favour productive sectors that are more willing to pay for the service, leading to an imbalance in productive activities. Sgobbi and Fraviga (2006) therefore recommends that the public sector acts as watchdog (i.e. the invisible hand), ensuring that increased efficiency in service delivery is not to the detriment of equity and social balance.

From the above it is clear that investments in the water sector require innovative financing mechanisms, including aspects like (Sgobbi and Fraviga, 2006):

- government institutions need to promote private investments,
- fostering public-private partnerships (PPP),
- implementing full cost recovery pricing systems,
- facilitating access to international funds for developing countries and
- access to micro-credit encouraging local development initiatives to focus on the water sector.

2.5.3 Water as strategic resource – the concept of Virtual Water (VW)

The concept of Virtual Water (VW) can be used to shape water management policies. VW refers to the quantity of water contained in a product, i.e. the amount of water needed to produce any given good. Allan (2003) explain that the concept of VW is often associated with comparative advantage. A country with scares water resources can therefore benefit by importing goods which require large quantities of water for production rather than overexploiting its own resources. In this way, real water use can be saved, relieving the pressure on local water resources or making water available for other uses. Stated otherwise, water-scares countries should specialise in the production of crops requiring less water.

World Water Council (2004) explains that the concept of virtual water import originated from empirical observations that food imports, especially cereal imports, have played a crucial role in compensating for the water deficit in water scarce countries. Figure 2.3 shows the major virtual water flows as a consequence of food trade, with the arrows indicating the net volumes exceeding 100 Gm^3. The major global water exports are from the Americas, South- East Asia and Oceania, whereas the major imports are from North Africa, Western Europe as well as Central and South Asia (World Water Council, 2004).

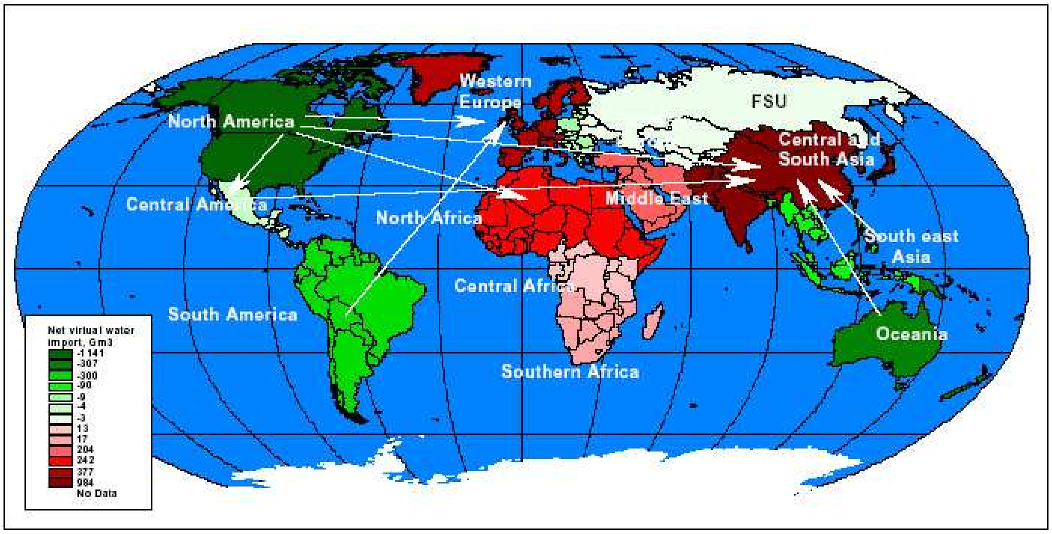


Figure 2.3: Major virtual water flows as a consequense of food trade between 1995 and 1999.

Source: World Water Council (2004)

2.5.4 Technological innovation

As explained above, technology forms an integral part of successful IWRM strategies, which in turn calls for technological innovation on more efficient water management. Sgobbi and Fraviga (2006) explain that technological innovation can be grouped in two main divisions, i.e. information technology and innovative technologies. Information and monitoring technologies, firstly, assist in the prediction of climatic events, water availability, real time water abstraction or regulation and well as market (economic) information on changes in global supply and demand together with corresponding market price outlooks.

Technological innovation (according to Allan (2003b)) may interest both the demand and supply side of water. Supply side technologies that can lead to increase in water availabilities include desalinisation and recycling of both industrial and agricultural water. Some examples on the demand side include, waste disposal techniques and more efficient irrigation technologies such as drip irrigation and hydroponics systems.

Important to realise is that technological innovation necessitate substantial investments in research and development. Sgobbi and Fraviga (2006) therefore urge governments, especially in developing countries, to provide incentives to both public and private development centres. Just as important as the research and development are the transfers of technologies and know-how, including that from developed to developing countries. This doesn't imply the viable transfers of all international developments; however, the adoption in the local context still remains.

2.5.5 Decision Support Systems

As explained earlier, successful IWRM, requires the application of innovative tools to facilitate the integration of different disciplines and perspectives within a common framework in order to facilitate trade-offs, exploit synergies and avoid policy conflicts. DSSRESOURCES (2007) explains that a Decision Support System (DSS) is a promising instrument to facilitate this trans-disciplinary integration which constitutes a family of computer-aided decision making instruments as well as the developing process thereof. More formally, the authors define DSS as "An interactive computer-based system or subsystem intended to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions".

The advantages of DDSs are that it can be used to explore different policy options, assessing their impacts, effectiveness and efficiency, as well as equity consequences, thus helping policy makers to take informed decisions. Sgobbi and Fraviga (2006) explain that DSSs are therefore useful for improving the decision making process for two main reasons: "Firstly, DSS tools inform decision makers and reduce the risks of inappropriate policies by facilitating the integration of inter-disciplinary knowledge and expertise, combining geographical, ecological, economic and social information. Secondly, the processes involved in developing DSSs tools can foster public participation in problem structuring and decision making, thus lending support and validating the underlying models, ensuring the assumptions are shared and realistic". DSSs can thus aid the objective policy making process by relying on strong scientific bases.

2.6 CONCLUSION

From the literature reviewed in this chapter it is clear that the field of macro-economic modelling is a very wide and well-researched field; however, new methodological frameworks are currently in the process of being developed internationally. It became clear from the discussion on the reviewed literature that there are considerable advantages to be derived from using the Northern Cape SAM instead of an I/O table for the province for purposes of macro-economic analysis. One of the major advantages is that a much more detailed analysis and therefore more valuable information will be generated by the proposed CGE framework, largely associated with the availability of social information in the economy. It is therefore recommended that the SAM-CGE framework, rather than the I/O analysis initially proposed, should be applied to achieve the main goals of this project as stipulated in the original contract.

CHAPTER 3

OVERVIEW OF THE NORTHERN CAPE ECONOMY, NATIONAL WATER RESOURCES AND IRRIGATION WATER REGULATIONS

3.1 INTRODUCTION 66
3.2 TOPOGRAHY, REGIONS AND POPULATION DEMOGRAPHICS IN THE NCP 68
3.3 DEMOGRAPHICS IN THE AGRICULTURAL SECTOR 71
3.4 AGRICULTURE AND HOUSEHOLD INCOME IN THE NORTHERN CAPE 72
3.5 ECONOMIC SECTORS 73
3.5.1 Primary industries 74
3.5.1.1 Agriculture, forestry and fishing 75
3.5.1.2 Mining and quarrying 85
3.5.2 Secondary industries 86
3.5.2.1 Manufacturing and processing 86
3.5.2.2 Utilities: Electricity/gas and water 87
3.5.2.3 Construction 87
3.5.3 Tertiary industries 87
3.5.3.1 Wholesale and retail trade; hotels and restaurants 88
3.5.3.2 Transport and communication 89
3.5.3.3 Finance, real estate and business services 89
3.5.3.4 Community, social and other personal services 89
3.6 IRRIGATION WATER AS A SCARCE ECONOMIC COMMODITY IN SOUTH AFRICA 89
3.7 CURRENT WATER REGULATION IN SOUTH AFRICA 92
3.7.1 The Water Policy 93
3.7.2 The Water Act 94
3.7.3 The National Water Resource Strategy 95
3.8 SUMMARY 96

List of Figures

FIGURE 3.1: MAP OF THE REPUBLIC OF SOUTH AFRICA ________ 66
FIGURE 3.2: THE DISTRICT MUNICIPALITIES OF THE NCP ________ 67
FIGURE 3.3: MAP OF THE NORTHERN CAPE PROVINCE ________ 68
FIGURE 3.4: REGIONS OF THE NORTHERN CAPE ________ 69
FIGURE 3.5: POPULATION DENSITY BY PROVINCE (PERSONS/KM^2) ________ 70
FIGURE 3.6: AGE DISTRIBUTION OF THE NC AND SOUTH AFRICAN POPULATION ________ 71
FIGURE 3.7: PROVINCIAL GDP CONTRIBUTIONS IN 2003 ________ 72
FIGURE 3.8: GROSS GEOGRAPHICAL PRODUCT BY SECTOR (% OF TOTAL IN 1999) ________ 74

FIGURE 3.9: PROVINCIAL CONTRIBUTION TO PRIMARY SECTOR GGP (1999) ____ 75
FIGURE 3.10: PROVINCIAL CONTRIBUTION TOWARDS THE NATIONAL TOTAL ____ 75
FIGURE 3.11: ESTIMATED CATTLE, SHEEP AND GOAT NUMBERS (QUARTERLY AVERAGE, NOVEMBER 2001 - NOVEMBER 2003) ____ 76
FIGURE 3.12: FAMING UNITS AND GROSS FARM INCOME ____ 78
FIGURE 3.13: EMPLOYEE REMUNERATION ____ 79
FIGURE 3.14: GROSS FARM INCOME BY AGRICULTURAL DIVISION AND REGION IN THE NCP __ 79
FIGURE 3.15: SHARE OF ARABLE CROPS IN THE NCP ____ 80
FIGURE 3.16: SHARE OF FIELD AND FODDER CROPS IN THE NCP ____ 80
FIGURE 3.17: REGIONAL ARABLE CROPS PRODUCTION IN THE NCP ____ 81
FIGURE 3.18: SHARES OF SELECTED HORTICULTURAL CROPS IN THE NCP ____ 82
FIGURE 3.19: REGIONAL PRODUCTION OF SELECTED VEGETABLES ____ 82
FIGURE 3.20: REGIONAL PRODUCTION OF SELECTED OTHER HORTICULTURAL CROPS IN THE NCP ____ 83
FIGURE 3.21: NATIONAL AREA UNDER CULTIVATION PER DECIDUOUS FRUIT TYPE ____ 84
FIGURE 3.22: REGIONAL GRAPE INCEPTIONS FOR THE 2005/06 SEASON ____ 85
FIGURE 3.23: PROVINCIAL CONTRIBUTION TOWARDS THE NATIONAL TOTAL ____ 86
FIGURE 3.24: PROVINCIAL CONTRIBUTION TOWARDS THE NATIONAL TOTAL ____ 88
FIGURE 3.25: LOCATION OF WATER MANAGEMENT AREAS AND INTER-WATER MANAGEMENT AREA TRANSFERS ____ 90
FIGURE 3.26: COMPARISON OF THE MEAN ANNUAL RUNOFF (MAR), POPULATION AND ECONOMIC ACTIVITY (GDP) PER WATER MANAGEMENT AREA ____ 91

List of Tables

TABLE 3.1: AVERAGE HOUSEHOLD INCOMES IN THE NORTHERN CAPE ____ 73
TABLE 3.2: NCP AGRICULTURAL REGIONS ____ 77
TABLE 3.3: NUMBER OF PAID EMPLOYEES PER AGRICULTURAL OCCUPATION IN THE NCP __ 78
TABLE 3.4: WATER REQUIREMENTS FOR THE YEAR 2000 (MILLION M^3/A) ____ 92

CHAPTER 3

OVERVIEW OF THE NORTHERN CAPE ECONOMY, NATIONAL WATER RESOURCES AND IRRIGATION WATER REGULATIONS

3.1 INTRODUCTION

The Northern Cape Province (NCP), situated in the north-western side of the country, is the largest in South Africa, covering almost 30% (361 830 km^2) of the total 1 219 090 km^2 of South Africa (see

Figure **3.1**). Despite being the largest province in terms of area, the Northern Cape's economy and population are considered the smallest of all provinces, basically relying on three economic sectors: agriculture, mining and community services. Despite its vast land area, more than 70% of its households live in urban areas.

The overview provided in this chapter is important as background to understand the inter-sectoral linkages between the different economic sectors involved when a shock is imposed on the economy or a specific sector.

Figure 3.1: Map of the Republic of South Africa
Source: DoA (2004)

Figure 3.2 shows the 5 district municipalities of the NCP. They are; Namakwa, Siyanda, Kgalagadi, Frances Baard and Karoo, none of which have metropolitan status. All urban areas are therefore classified as either small cities or towns. According to SSA (2002a), the most densely populated district is Frances Baard with approximately 35% of the population, followed by Siyanda (28.5%), Karoo (19.5%), Namakwa (14.4%) and lastly Kgalagadi (2.6%).

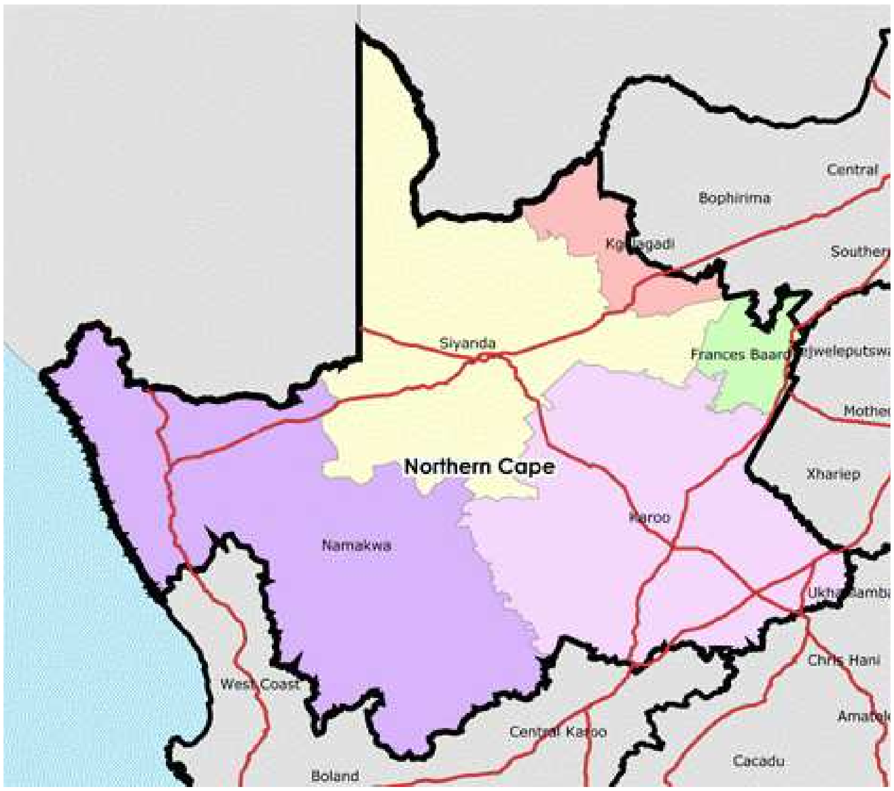


Figure 3.2: The district municipalities of the NCP
Source: Demarcation Board (2006)

In this chapter, the different economic sectors of the NCP are identified and described in the next section in terms of the rest of South Africa in order to provide a better understanding (contextualization) of the relative importance of the different sectors. The Standard Industry Classification (SIC) system was used to divide the economy into nine sectors, further grouped into primary, secondary and tertiary industries. First of all, an overview of the Northern Cape Province is provided, followed by a short description of the nine different economic sectors. Due to the focus of this thesis on agriculture and more specifically on irrigation agriculture, more attention is provided to the arable crops grown in the NCP. In the third section, irrigation water as scares economic good are dealt with due to the importance thereof in the study. This is followed by an overview of the current South African water regulations in the fourth section and the chapter is thereafter concluded in the fifth section.

3.2 TOPOGRAHY, REGIONS AND POPULATION DEMOGRAPHICS IN THE NCP

Despite the fact that the Northern Cape's topography is classified overall as semi-desert, the natural beauty and wildlife attract a significant number of tourists each year. Approximately 11% of South Africa's national parks and major nature reserves are within the NCP (see Figure 3.3). The major towns of the Northern Cape include Kimberley, Kuruman, Upington, De Aar, Calvinia and Springbok.

Figure 3.3: Map of the Northern Cape Province
Source: Northern Cape Provincial Government (2004)

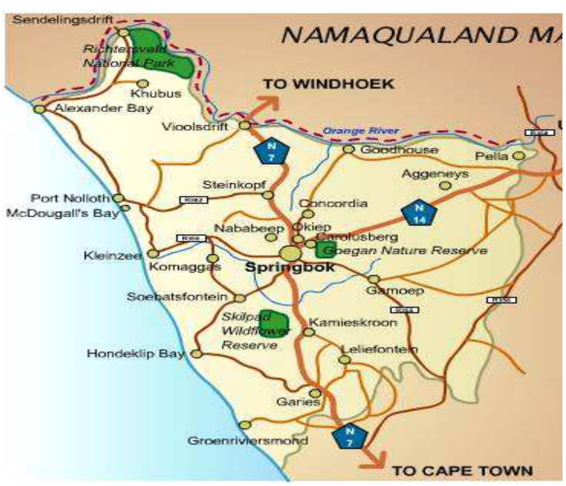
Overall, the Northern Cape Provincial Government (2004) divides the Northern Cape Province into four main districts: Diamond Fields, Kalahari, Namaqualand/Lower Orange and the Upper Karoo (see Figure 3.4). Figure 3.4a shows the Diamond Fields with Kimberley as the provincial and regional capital. As its name indicates, the region is famous for its natural diamond and mineral wealth. Agriculture in this region consists mainly of natural grazing for sheep, beef and game as well as crop production, including maize, wheat, cotton, ground nuts, lucerne, grapes and soy beans, mainly irrigated from the Vaal and Orange rivers.

Figure 3.4b shows the very dry, semi-desert Kalahari region. Agricultural activities in the region are mainly limited to extensive livestock grazing and game ranging. Also included in this region is the lower part of the Orange River, with Upington as the capital of the region, serving as both an administrative and commercial centre. Despite being generally very dry, the Orange River runs through the region, crossing rich cultivatable farm land. Running from the east to west, its banks are weltered with irrigation farms, where a variety of cash crops and perennial crops are grown.

The Namaqualand region, shown in Figure 3.4c, is known for its extravagant perennial spring flower display, which occur annually between August and October (Northern Cape Provincial Government, 2004). Except for the mining of rich mineral deposits, diamonds and other precious stones, economic activities in this region are mainly limited to extensive livestock farming.

a – Diamond Fields

b - Kalahari



c - Namaqualand

d - Upper Karoo

Figure 3.4: Regions of the Northern Cape
Source: Northern Cape Provincial Government (2004)

The semi-arid Upper Karoo region is shown in Figure 3.4d. Analogous to the Diamond Fields and Namaqualand, the Upper Karoo is sprinkled with small towns/villages originating from earlier diamond diggings. Farm land in the region is highly suited to sheep farming, including merino and fat-tailed sheep. Colesberg is a very important stopover for travellers on the main road (N1) leading from Cape Town in the south to Musina (via Johannesburg and Pretoria) in the north. Renowned towns and other interesting places in this region include Hopetown, Richmond, Van der Kloof Dam, the Rolfontein and Doornkloof Nature Reserves (Northern Cape Provincial Government, 2004).

The fact that the NCP economy is considered to be the smallest of all provinces in South Africa can, for example, be ascribed to factors such as a relatively low annual rainfall and a small population. Nationally, the Northern Cape receives the lowest annual rainfall, with only 414 mm on average measured in and around Kimberley in the east and as low as between 100 mm and 200 mm around Calvinia in the south-east to the Richtersveld in the north-west (NDM, 2007).

Despite being the largest province in terms of area, the NCP is the least densely populated province in South Africa, with only 2% of the national population living in the Northern Cape. Population densities expressed in persons per km^2, per province as well as the national average are shown in Figure 3.5. It is furthermore clear that the Northern Cape Province's population density is far below the South African average with only 2.5 persons per km^2 compared to the 36.2 persons per km^2 on average living in South Africa.

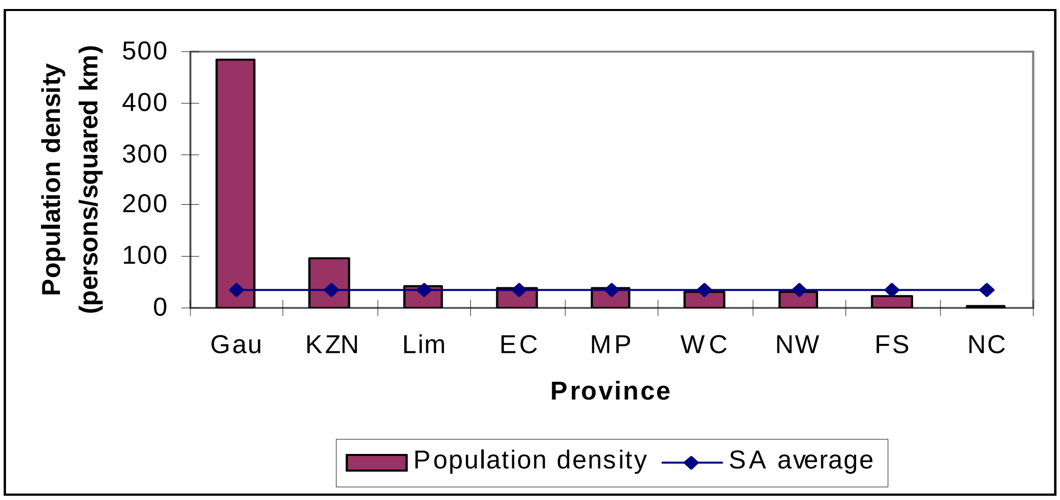


Figure 3.5: **Population density by province (persons/km^2)**
Source: *Du Toit (2001)*

According to the latest estimates, of the 902 232 people living in the Northern Cape, the majority (approximately 70%) is Afrikaans speaking, followed by Setswana (20.1%), IsiXhosa (6.5%) and English (2.3%). Unlike other provinces, the dominant race group is coloureds (51.7%), followed by blacks (33.9%), whites (14.2%) and Asians (0.3%).

On average, the Northern Cape has had the lowest national population growth rate, measured at 1.3% per annum between 1997 and 1999, slightly below the average of 1.5% for South Africa as a whole over the same period. The race group growing the fastest is blacks with 1.6%, followed by coloureds (1.4%), Asians (0.8%) and whites (0.2%).

Interestingly enough, despite having a relatively small population and "poor" economy, on average, the state of human development in the Northern Cape is rated the third highest in South Africa. According to the Wharton Econometric Forecasting Association (WEFA), the average Human Development Index (HDI) calculated for the Northern Cape is 0.555, ranging from 0.846 for whites to 0.462 for blacks.

In terms of urbanisation, the Northern Cape is the third most urbanised province in South Africa, with 70.4% of the total population living in towns or cities in the Northern Cape. In terms of race, 89.6% of Asians, 77% of Blacks, 72.6% of Whites and 63.7% of Coloureds in the Northern Cape were living in urban areas during 1999.

The age distribution of the Northern Cape's population is basically identical to the average age distribution of the South African population as a whole (see Figure 3.6). Important to note is that the majority 54% of the population in both cases is less than 30 years old.

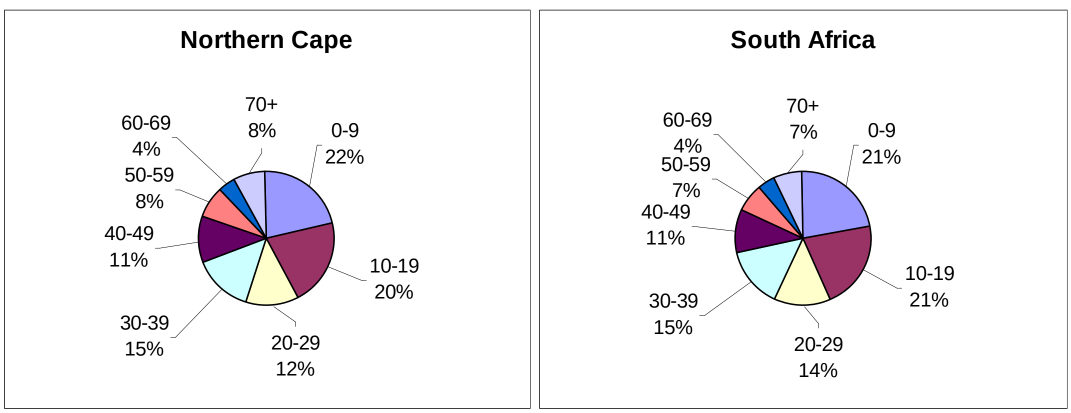


Figure 3.6: Age distribution of the NC and South African population
Source: Du Toit (2001)

3.3 DEMOGRAPHICS IN THE AGRICULTURAL SECTOR

According to Provide (2002), the Income and Expenditure Survey (IES) is the only source of information on home production for home consumption (HPHC). Provide (2002c) reports further that approximately 12.5% of households in the NCP are involved in HPHC, which is less than the national average of 19.3%, whereas 22.2% earn some share of their income from wages of household members working in agriculture-related industries. Income differences in the Income and Expenditure Survey suggest that white households are typically the owners or managers of farms with average incomes of R 190 909. African and Coloured households typically supply farm labour, with average incomes of R 11 625 and R 13 049 respectively (SSA, 2002a).

Provide (2005c) shows that when households in own production (HPHC) and agricultural employment are combined, 28.8% of the Northern Cape households can be defined as agricultural households, consisting in total of 29% Africans, 55.4% Coloureds and 15.6% Whites. Two definitions are used to classify agricultural households, i.e. strict and broad definition. Under the strict definition, a household has to earn at least 50% of its household-level income from formal and/or informal agricultural activities, whereas any household that earns income from either formal employment in the agricultural industry or as a skilled agricultural worker, or from sales or consumption of home produce or livestock, is defined as an agricultural household under the broad definition. In terms of the magisterial districts, Siyanda has the highest proportion of agricultural households at 26.5% according to the strict definition and 29.2% according to the broad definition followed by Namakwa (22.7% – 30.7%), Pixley ka Seme (previously Karoo) (23.2% - 31.9%), Kgalagadi (15.7% - 19.6%) and Frances Baard (11.4% - 18.1%). SSA (2002b) suggests that over a quarter (25.6% to be exact) of the NC's workforce was employed in the agricultural sector in 2000, loosely defined as skilled agricultural workers or working in the agricultural industry either in a formal or informal capacity.

3.4 AGRICULTURE AND HOUSEHOLD INCOME IN THE NORTHERN CAPE

According to Figure 3.7, the NCP is the smallest contributor to the national Gross Domestic Product (GDP) with only 2.4%. It should, however, be kept in mind that only 1.8% of the South African population lives in the NCP, resulting in an above national average per capita GDP of R 15 474 compared to R 12 411.

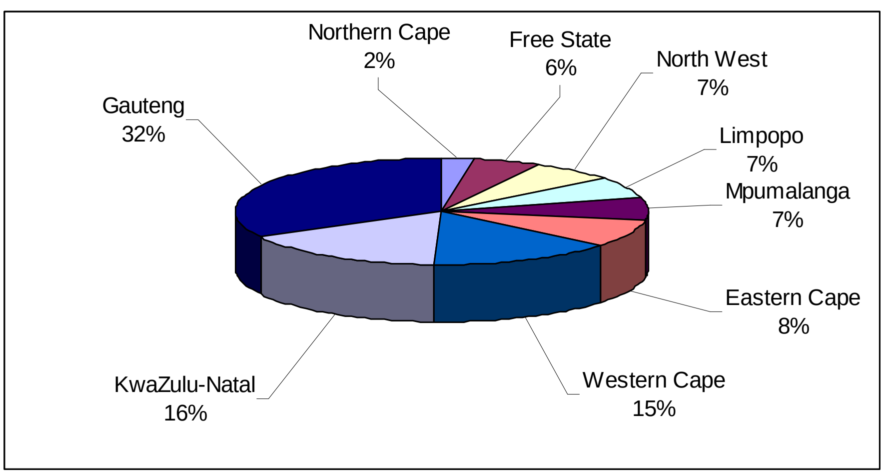


Figure 3.7: Provincial GDP contributions in 2003
Source: SSA (2003b)

The average household income for various subgroups of agricultural and non-agricultural households (according to the strict definition) in 2000 is reported in Table 3.1. An interesting phenomenon is that White agricultural households in general earn more (R 296 390) than their non-agricultural counterparts (R 166 629), with the opposite being true for their African and

Coloured counterparts (Provide, 2005c). From the Table, it is clear that, on average, agricultural households earn R 71 069 compared to R 55 377 for non-agricultural households. African agricultural households are worse off, earning on average R 11 424 annually compared to R 27 887 for their non-agricultural counterparts. The same is true for Coloured households, earning on average R 18 861 in the agricultural sector compared to R 35 937 for their non-agricultural counterparts. In terms of income distribution, the Gini coefficient for the NCP is 0.73, which is higher than the national Gini coefficient of 0.69 (SSA, 2002a as in Provide, 2005c). The Gini coefficient varies between 0 and 1. In reality, values usually range between 0.2 and 0.3 for countries with a low degree of inequality and 0.5 and 0.7 for countries with highly unequal income distributions.

Table 3.1: Average household incomes in the Northern Cape

	Agricultural Households					Non-agricultural households				
	African	**Coloured**	**Asian**	**White**	**Total**	**African**	**Coloured**	**Asian**	**White**	**Total**
Namakwa	12,955	23,347	-	142,333	51,696	19,712	40,601		134,049	59,603
Siyanda	9.606	23,864	-	404,402	102,690	32,647	22,643		227,389	69,750
Kgalagadi	13,618		-	505,200	170,288	28,676			187,186	48,227
Frances Baard	12,425	15,242	-	242,218	46,133	30,728	56,730	187,983	158,670	57,111
Karoo	11,158	10,164	-	242,370	43,008	13,499	26,159		84,454	29,353
Provincial average	*11,424*	*18,861*	-	*296,390*	*71,069*	*27,887*	*35,937*	*187,983*	*166,629*	*55,377*
National average	***15,014***	***24,250***	***132,816***	***282,151***	***26,612***	***29,777***	***57,284***	***88,642***	***166,100***	***49,990***

Source: Provide (2005c)

These agricultural households typically reside in rural areas and are therefore removed (often ~~in~~ by large distances, especially in the NCP, with poor transport infrastructure) from more lucrative employment opportunities in urban areas. Poverty rates in the NCP, as measured by the 40th percentile cut-off point of adult equivalent per capita income, with the 20th percentile cut-off being an “ultra-poverty line”, are marginally below (0.3%) the national rates of 49.8% for the 40th percentile cut-off point, and quite substantially (6.9%) below the 28.2% average of the 20th percentile cut-off point for the total population. Provide (2005c) reports that poverty rates vary greatly between racial groups, with virtually no poverty among White and Asian people compared to the 53.3% and 58.7% of Coloured and African people respectively, who are classified as poor. Two interesting points are further worth mentioning. Firstly, the proportion of people living in poverty is lower in rural areas (44% compared to 50.3% in urban areas). Secondly, a larger proportion of agricultural households are poor (54.8% compared to 47.7%).

3.5 ECONOMIC SECTORS

The contribution of the different economic sectors towards the total Gross Geographical Product (GGP) in the Northern Cape and South Africa as a whole is shown in Figure 3.8. It is clear that the contribution of the Northern Cape's primary and secondary economic sectors differs considerably from the national average.

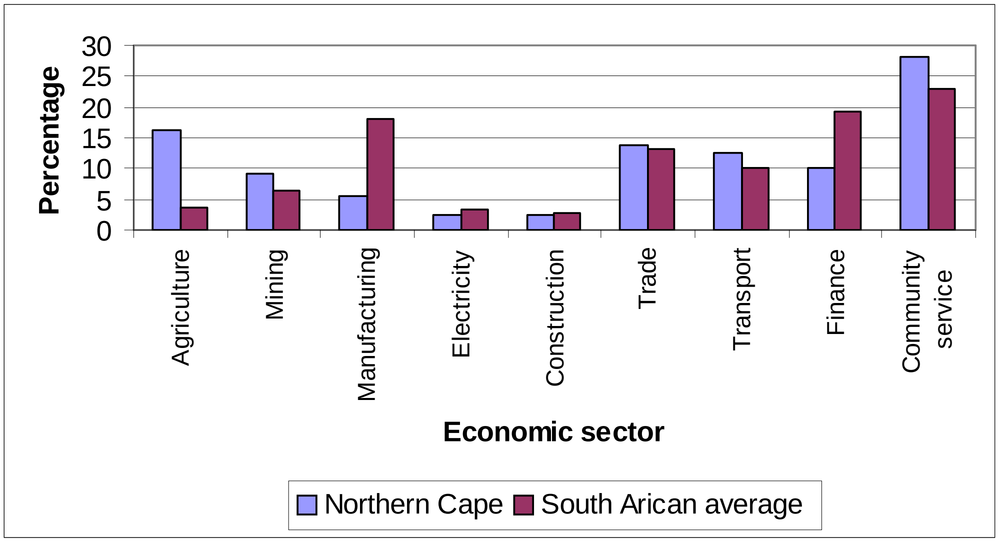


Figure 3.8: **Gross geographical product by sector (% of total in 1999)**
Source: *Du Toit (2001)*

During 1999, the Northern Cape's primary industries (agriculture and mining) contributed 25.2% towards the GGP, compared to the national average of 10.2%. In terms of secondary industries (manufacturing, electricity and construction), the Northern Cape's contribution is considerably lower than the national average, with 10.5% compared to the national average of 24.4%. The contribution of tertiary industries (trade, transport, finance and community service) towards the GGP of 64.3% in the Northern Cape compares well with the national average of 65.4%.

3.5.1 Primary industries

Compared to other provinces, the Northern Cape's primary sector is the second smallest (see Figure 3.9), contributing only 4% towards the total primary sector of the South African economy. The largest contributors towards the primary sector during 1999 were the North West province (24%) followed by Gauteng (18%) and Mpumalanga (15%). In the next sub-section, due to the agricultural focus of this project, a more detailed (compared to the other economic sectors) overview is provided of the agricultural sectors in the NCP.

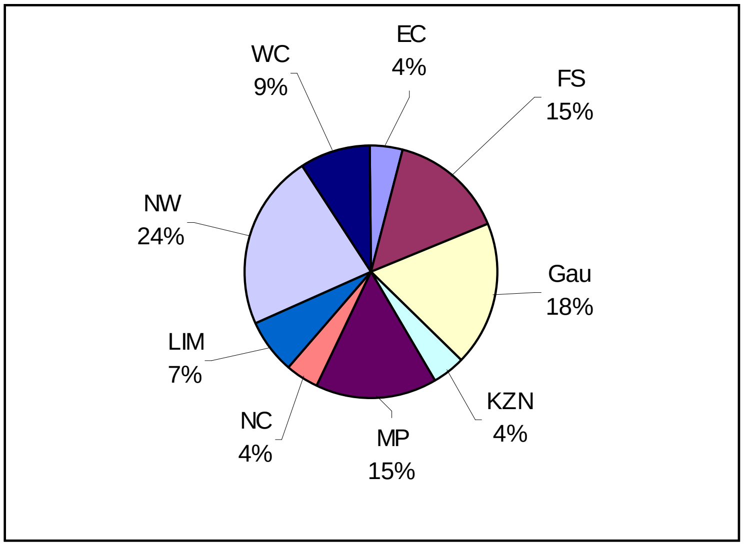


Figure 3.9: Provincial contribution to primary sector GGP (1999)
Source: Du Toit, 2001

3.5.1.1 Agriculture, forestry and fishing

This sector incorporates all establishments that are primarily engaged in farming activities as well as commercial hunting, game propagation, forestry, logging and fishing. In terms of agriculture, forestry and fishing, the Northern Cape is producing 7.7% (third smallest) of the national aggregate (see Figure 3.10). Although relatively small in terms of national production, this sector accounts for 16.1% of the regional economic output (see Figure 3.8 above). In value terms during 1999, this represented R2.04 billion worth of production.

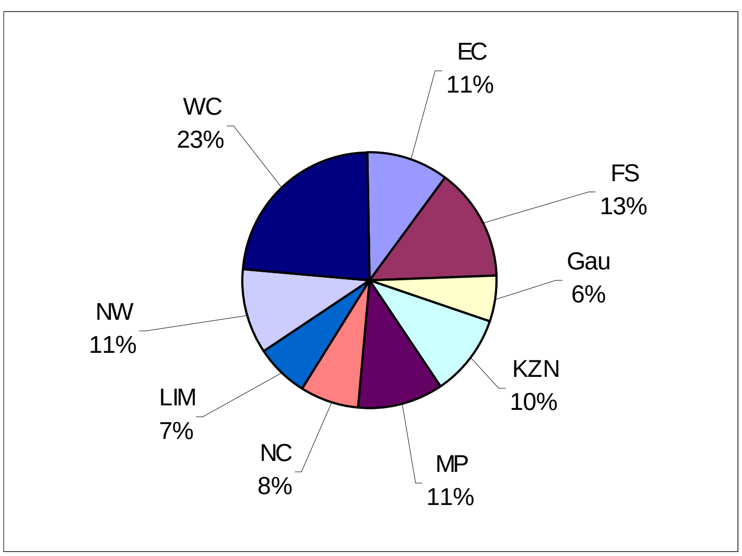


Figure 3.10: Provincial contribution towards the national total agricultural production
Source: Du Toit (2001)

Despite being drier than other provinces, the Northern Cape has fertile agricultural land on which some of the finest quality agricultural products are produced. As mentioned, the Northern Cape is characterised as semi-desert, and although very dry, one of the Northern Cape's most prevalent assets is the network of rivers running through and bordering the province. Irrigation agriculture therefore plays a vital role in the provincial economy, whereas rain-fed cultivation is considered insignificant. The main crops that are grown under irrigation include groundnuts, maize, wheat, lucerne, grapes (table and wine), cotton and soybeans. Except for irrigated crops and orchards, the remaining agricultural production mainly comes from extensive livestock husbandry, like beef, mutton, wool, mohair, karakul pelts and game.

The estimated number of beef, sheep and goats per province is shown in Figure 3.11. It is clear that the Northern Cape had the second largest provincial sheep population, 27.3% of the national total, on average from November 2001 to November 2003. In the case of goats, the Northern Cape is the province with the fifth largest number of goats in the Republic, representing 7.5% of the national goat flock. In terms of cattle, only 3.5% of the national cattle herd is found in the Northern Cape, making it the province with the second smallest cattle numbers. In terms of more intensive livestock operations like pigs, only 1% of national pig numbers are found in the Northern Cape (not shown).

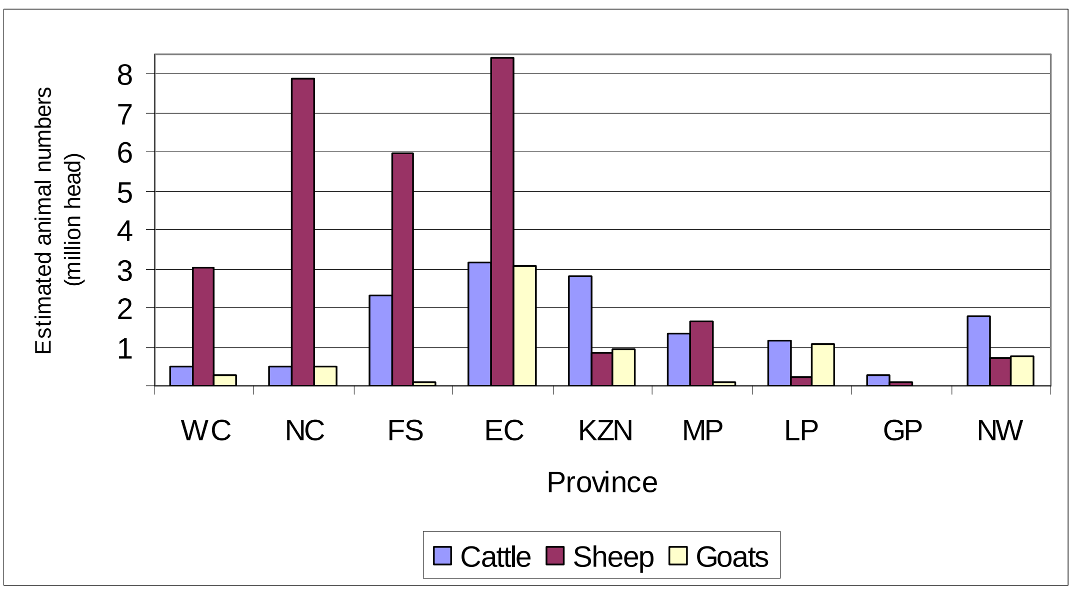


Figure 3.11: Estimated cattle, sheep and goat numbers (quarterly average, November 2001 - November 2003)
Source: NDA (2003)

With an abundance of marine resources, South Africa is one of the world's premier fishing nations. South Africa's western coastal shoreline, most of which lies in the Northern Cape Province, is an extremely profitable area for fishing and aquaculture (Northern Cape Provincial

Government, 2004). Around the Northern Cape's principal port, Port Nolloth, the waters are unpolluted, nutrient-rich and abundant in marine life.

Farm units and Gross Farm income

The major towns in the NCP, grouped into the following eight regions (NC1 to NC8) by PROVIDE (2006), are shown in Table 3.2. To facilitate cross referencing and comparison later with the results, these same groupings are used.

Table 3.2: NCP agricultural regions

Region	Major towns in statistical region
NC1	Gordonia, Namakwaland (Including Upington, Springbok) and Kenhardt
NC2	Calvinia, Sutherland and Williston
NC3	Fraserburg, Victoria West
NC4	Hopetown, Britstown, De Aar, Philipstown, Richmond, Hanover, Colesberg and Noupoort
NC5	Kuruman, Postmasburg and Hay
NC6	Prieska and Carnarvon
NC7	Herbert, Barkly West, Warrenton and Hartswater
NC8	Kimberley

Source: PROVIDE (2006)

The farming units and gross farm income of the NC farms per region are shown in Figure 3.12. Accoding to the 2002 Agricultural Senses (StatsSA, 2002b), there are 1 828 farming units in NC1 (i.e. Gordonia, Namakwaland and Kenhardt). This region does not only have the largest number of farming units of the eight regions in the NCP, but the aggregate Gross Farming Income is also the highest, being nearly R 1.4 billion in 2002. In terms of the other regions, the second highest number of farming units are in NC5 (1 023) followed by NC7 (936) and NC4 (768). The region contributing the second largest share to GFI is NC7 (R 786 million) followed by NC4 (R 406 million), NC6 (R 275 million) and NC5 (R 262 million).

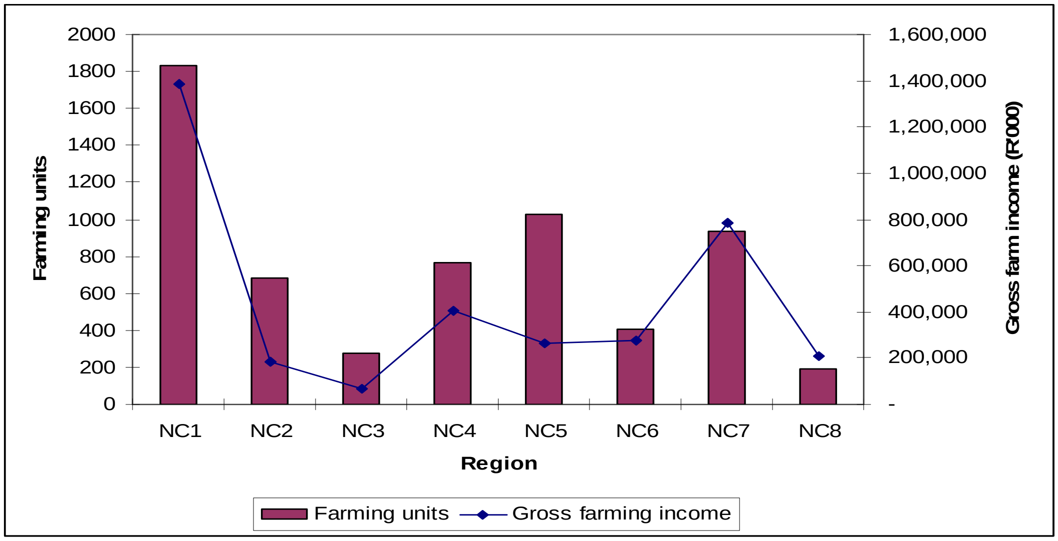


Figure 3.12: Faming units and gross farm income
Source: STATSSA (2002b).

Agricultural employment in the NCP

The number of paid employees per gender and occupation in the agricultural industry is shown for the eight regions in Table 3.3. In total nearly 100 000 full and part-time employees are employed in the agricultural sector in the NCP. As in the previous section, NC1 is the most important employing region, with nearly 64% of the total employment in the agricultural sector in the NCP. Of these 63 519 employees, 45 393 (or 71%) are casual or seasonal workers.

Table 3.3: Number of paid employees per agricultural occupation in the NCP

Region	Number of paid employees								
	Total			Farm managers/ foreman		Full- time employees		Casual and seasonal workers	
	All	Male	Female	Male	Female	Male	Female	Male	Female
NC1	63519	36299	27220	686	68	13256	4115	22357	23036
NC2	1401	1162	239	69	5	481	62	612	172
NC3	945	713	232	51	10	524	150	138	72
NC4	6004	4167	1837	190	25	2059	717	1920	1094
NC5	1418	1150	268	92	2	549	86	509	181
NC6	4710	3186	1524	115	11	1244	104	1828	1409
NC7	16646	10460	6186	222	25	3962	533	6277	5628
NC8	4605	3321	1284	71	5	1375	216	1875	1064
Total	99248	60458	38790	1496	151	23450	5983	35516	32656

Source: STATSSA (2002b).

The remuneration paid to full time and casual and seasonal agricultural workers is shown in Figure 3.13. The part time employees in NC1 (71% from above) earn 38% (not shown explicitly in the Figure) of the total regional remuneration paid to agricultural workers. This is significantly higher than the average of 14.5% paid to seasonal or casual workers in the other seven regions.

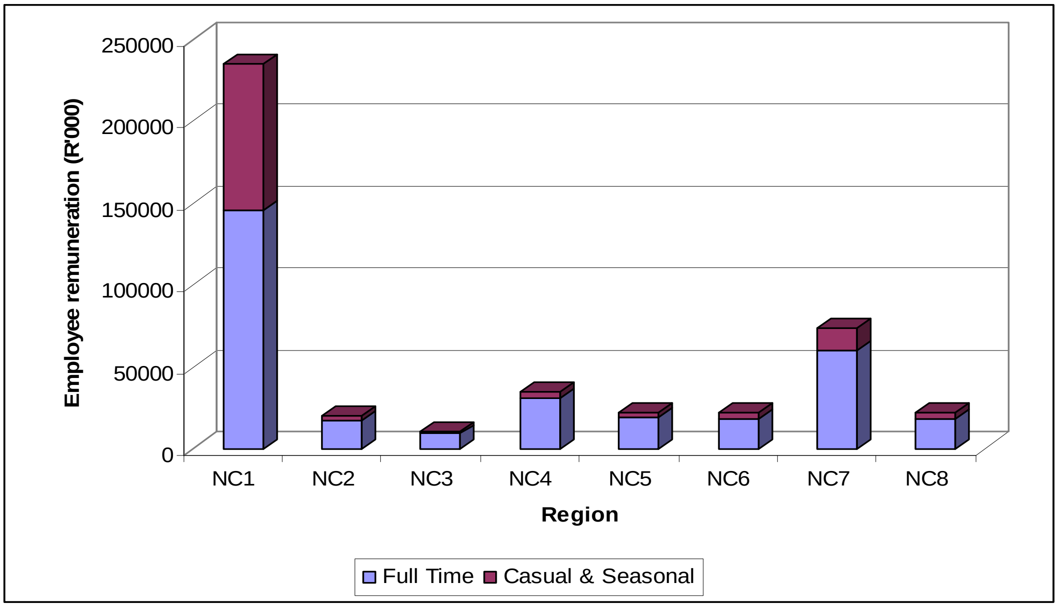


Figure 3.13: Employee remuneration
Source: STATSSA (2002b).

Gross Farm Income (GFI)

The regional GFI for the main agricultural commodities in the NCP is shown in Figure 3.14. Horticulture is by far the most important in NC1, whereas NC2 to NC5 are dominated by animal products and NC6 to NC8 are dominated by field crops in turn.

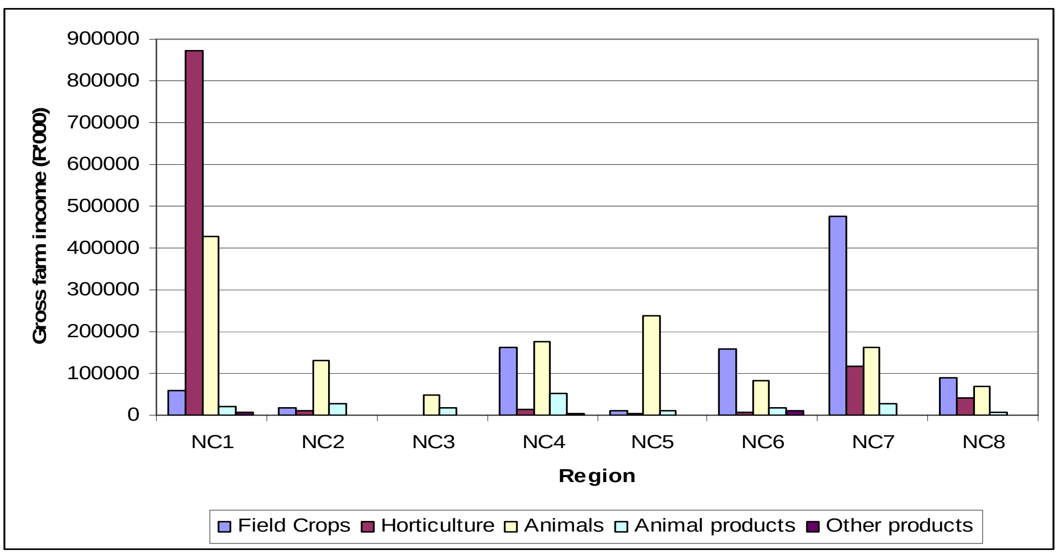


Figure 3.14: Gross Farm Income by agricultural division and region in the NCP
Source: STATSSA (2002b).

The seven arable crops as a group contribute nearly 60% in value terms to the total primary agricultural production (arable crops and livestock) in the NCP (PROVIDE, 2005b). The value shares of the irrigated crops are shown in Figure 3.15: **Share of arable crops in the NCP** of which fruit contributes 41% of the total arable crop production in the NCP in value terms.

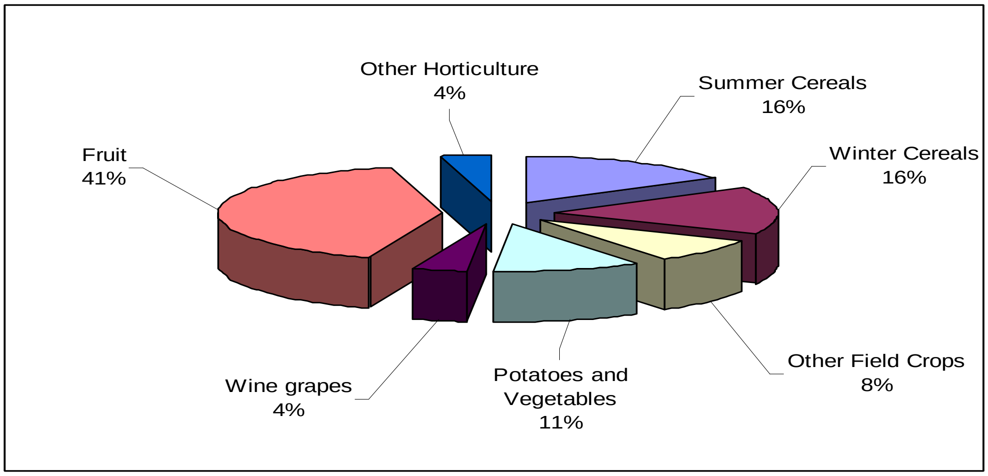


Figure 3.15: Share of arable crops in the NCP
Source: STATSSA (2002b).

Field and fodder crops

In terms of the major field and fodder crops produced in the NCP, maize, wheat and lucerne combined carry a 94% share in terms of total physical output of these crops. The other major field and fodder crops include barley, groundnuts, grain sorghum and maize for silage. It is important to remember that maize and wheat is used quite extensively in a double cropping system under irrigation on the same land.

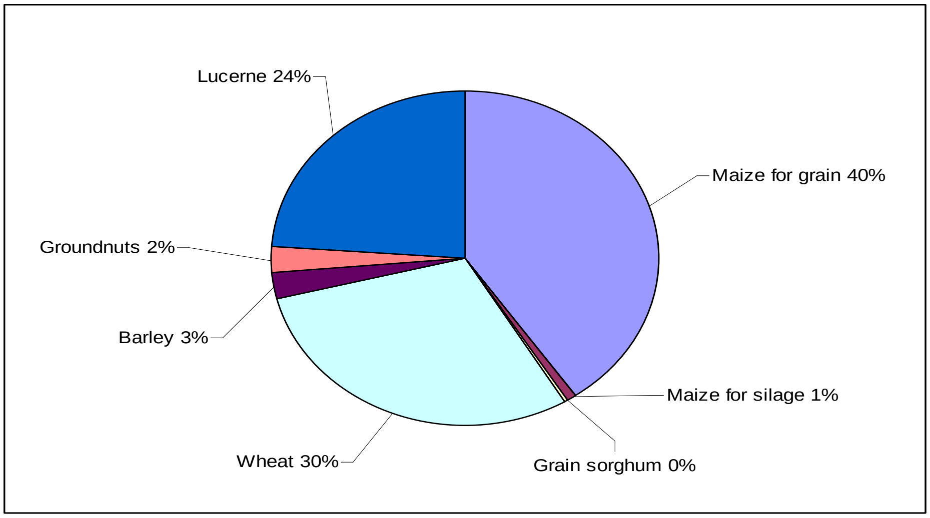


Figure 3.16: Share of field and fodder crops in the NCP
Source: STATSSA (2002b).

The regional distribution in terms of physical outputs of the major arable crops (shown above) is shown in Figure 3.17. In terms of physical output (tonnes) NC7 are producing the most arable crops of which maize contributes almost 40% followed by wheat (30%) and lucerne (20%). Other regions where maize and wheat form a major part are: NC4, NC6 and to a lesser extent NC8.

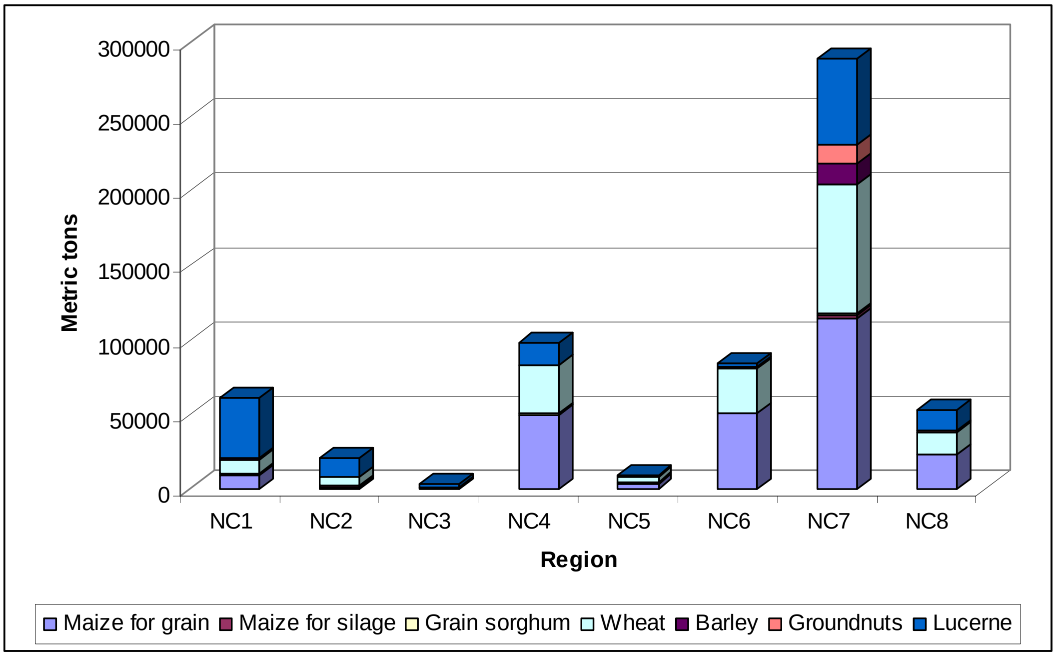


Figure 3.17: Regional arable crops production in the NCP
Source: STATSSA (2002b).

Horticultural crops

The output shares of the horticultural crops produced in the NCP are revealed in Figure 3.18. The three major horticultural products produced in the NC, are: table grapes (38%) followed by potatoes (31%) and wine grapes (20%).

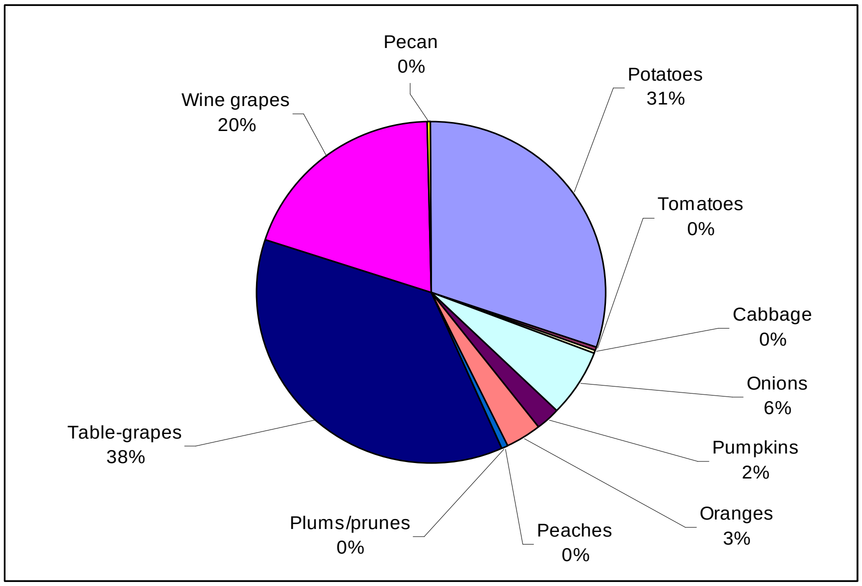


Figure 3.18: Shares of selected horticultural crops in the NCP
Source: STATSSA (2002b).

The regional outputs of selected vegetables (i.e. potatoes, tomatoes, cabbage, onions and pumpkins) are shown in Figure 3.19. Potatoes are extremely prominent in NC4, NC7 and to a lesser extend NC8 and NC6.

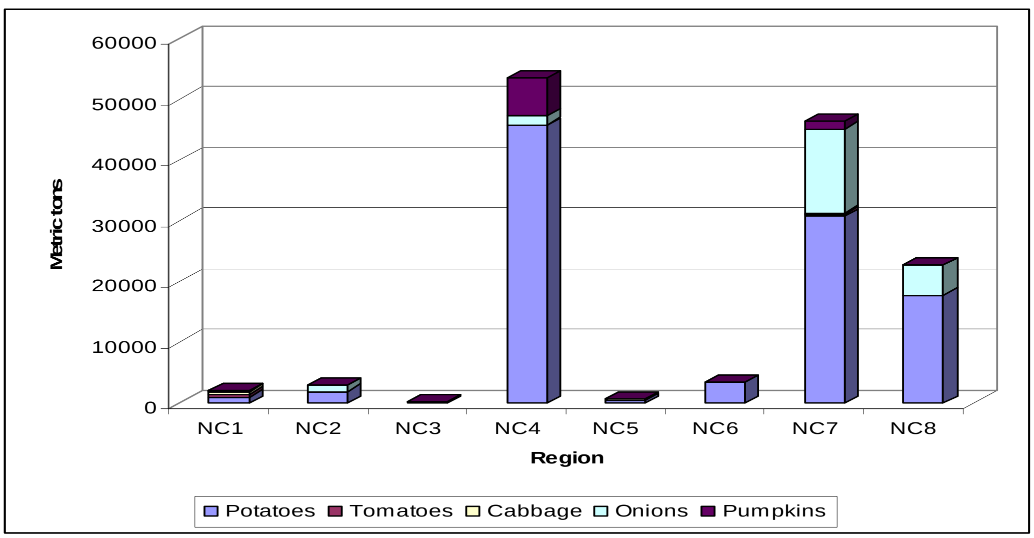


Figure 3.19: Regional production of selected vegetables
Source: STATSSA (2002b).

The regional output of other selected horticultural crops (i.e. table grapes, wine grapes, oranges peaches and plums) are shown in Figure 3.20, where the "lion's share" is produced in NC1 (i.e. Gordonia, Namakwaland and Kenhardt). Nearly two-thirds (64%) of the total horticultural output in NC1 is made up by table grapes followed by wine grapes (33%). In this group of horticultural products, oranges produced in NC7 are the only other crop produced at a relative significant level.

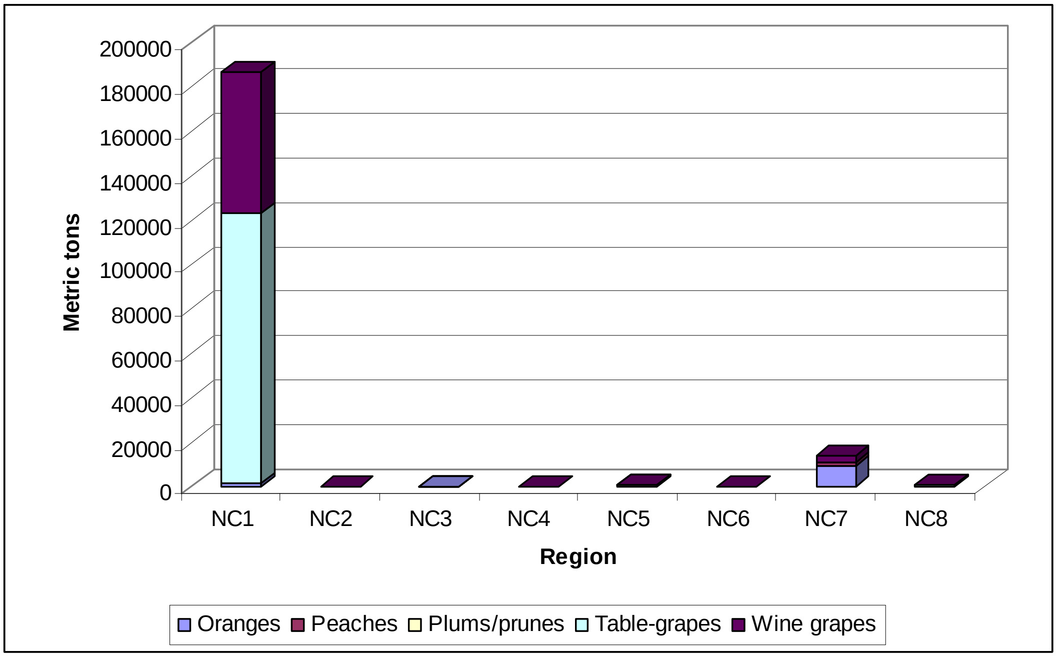


Figure 3.20: Regional production of selected other horticultural crops in the NCP
Source: STATSSA (2002b).

Since the turn of the century, farmers experienced bumpy rides, with some industries more so than in others. The South African Table Grape Industry (SATI) is one of those industries that have seen very difficult production and marketing seasons. As explained earlier, table grapes contribute significantly to the total agricultural output in the NCP and more importantly, play an important role in irrigation agriculture in the NCP. South African fruit exports contribute 1.3% to the total commodity export earnings. In terms of all primary agricultural commodities fruit earn 43% of the foreign exchange, which increases to 54% if primary arable crops are used as denominator.

The production costs of fruit, and more specifically table grapes, in the NCP are significantly higher compared to other regions locally and internationally. This higher cost of production puts the profitability of these producers under enormous pressure as output prices vary, especially in the international markets where the exchange rates further complicate the task.

According to OABS (2006), table grapes and dry grapes (raisins) together comprise approximately 95% of the total value of fruit production in the NCP (see also Figure 3.21 for a national comparison).

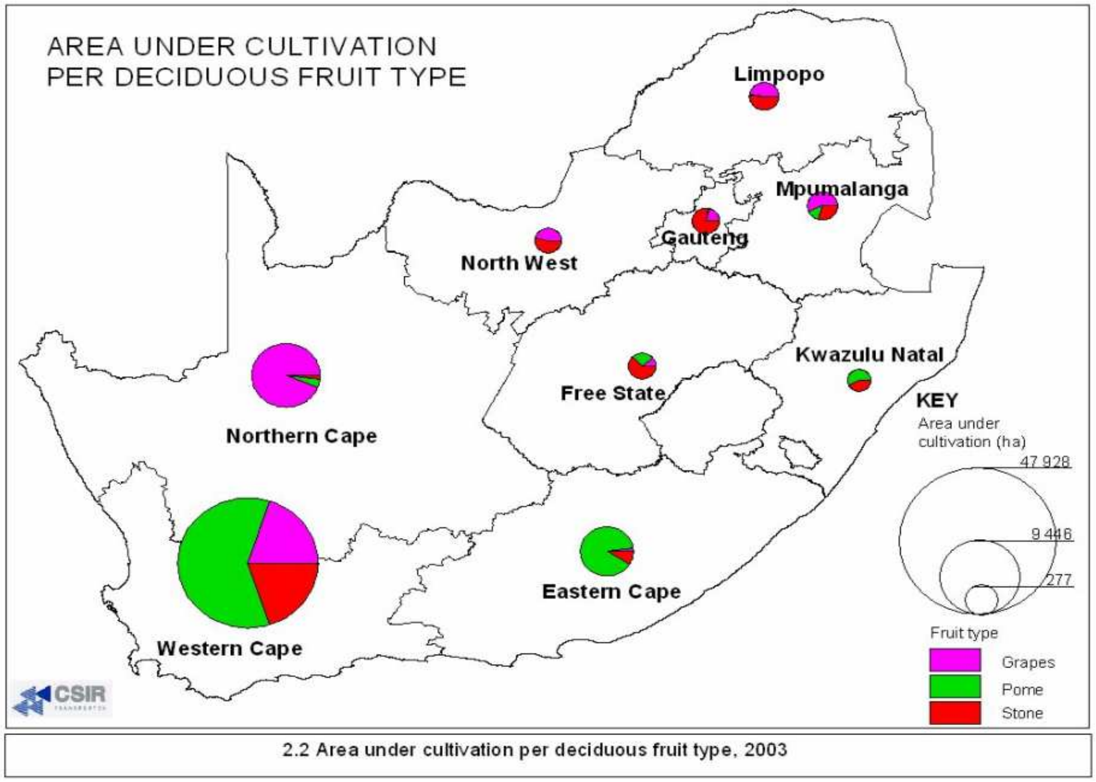


Figure 3.21: National area under cultivation per deciduous fruit type
Source: CSIR (2003)

Figure 3.22 shows the table grape inceptions per region for the 2005/06 season. Its is clear that, except for the Limpopo that starts three weeks earlier, the NCP (Orange River) dominates the first half of the table grape delivery season. This "early producer advantage", NC table grape producers had over other major table grape producing regions (locally and internationally), realised exceptionally higher prices on the European markets in the past, providing a signal to NCP irrigators to increase their table grape production.

According to Louw *et al.* (2007). due to the increased international competition, mainly from Latin American countries (including Brazil, Argentine and Chile), the NCP has lost the competitive advantage it enjoyed in the early slot of season.

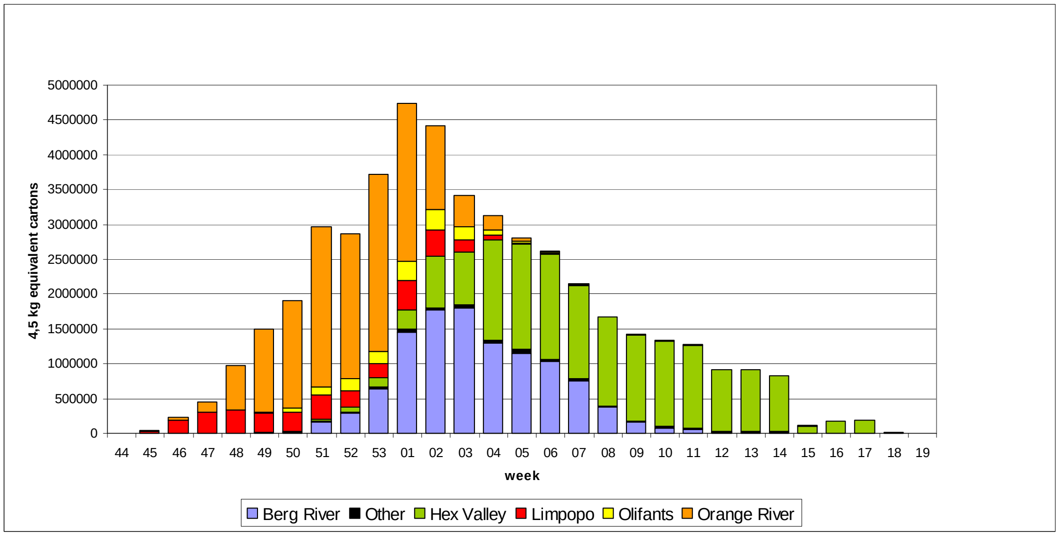


Figure 3.22: Regional Grape inceptions for the 2005/06 season
Source: OABS (2006)

3.5.1.2 Mining and quarrying

This sector includes the extracting and beneficiation of naturally occurring minerals, including solids, liquids, and crude petroleum and gases. It also includes underground and surface mines, quarries and the operation of gas and oil wells, as well as the supplemental activities of dressing and beneficiation of ores and other crude materials (Urban-Econ, 2004).

Mining accounts for a major proportion of South Africa's annual export earnings. Despite the fact that the Northern Cape is considered rich in precious stones and minerals, the provincial contribution towards the total national mining and quarrying production amounts to only 2.4% (see Figure 3.13). The mining industry in the Northern Cape revolves around the production of semiprecious stones, ores and minerals.

During 1998, the Northern Cape produced approximately 37% of the country's diamonds, 44% of its zinc, 70% of the silver, 84% of the iron ore, 93% of the lead and 99% of its manganese. According to the Northern Cape Provincial Government (2004), some of the mining giants that operate in the Northern Cape are Samancor, Iscor, Goldfields, PPC Lime, Alpha Assmang and Anglo American.

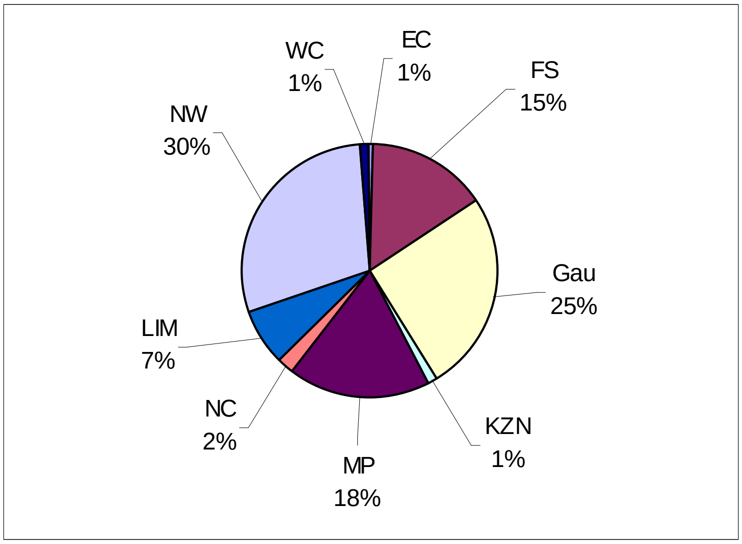


Figure 3.23: Provincial contribution towards the national total Mining and Quarrying production income (1999)
Source: Du Toit (2001)

According to Du Toit (2001), the Northern Cape's mining industry only employed 4.8% of those in the national mining industry as a whole. In relation to other provinces, the Northern Cape was the fifth largest contributor in terms of income earned on primary mineral sales during 2001, which represents 5.9% of the national local sales compared to 8.2% of total export sales.

3.5.2 Secondary industries

Historically, the Northern Cape region has focused on agriculture and mining, but during the last decade, increased attention has also been given to broadening the industrial base of the province. Compared to the rest of South Africa, the Northern Cape's secondary sector contributed a mere 0.8% (R 1.4 billion) towards the national secondary GGP. In terms of all three secondary industry sectors, the Northern Cape is by far the smallest contributor compared to other provinces.

3.5.2.1 Manufacturing and processing

Manufacturing and processing can formally be defined as the physical or chemical transformation of materials or compounds into new products. In general, factories in the Northern Cape tend to be small, employing 32 people on average (Northern Cape Provincial Government, 2004).

The bulk of manufacturing activities in the province is concentrated in the urban areas of Kimberley and Upington. Manufacturing in the Northern Cape is dominated by the food and beverage, clothing, textile and metal industries. Over the period 1990 to 1999, the manufacturing sector in the Northern Cape grew by 6.8% compared to the 0.3% national growth rate. Employment in the Northern Cape's manufacturing sector rose by 3.6% from 8 897 employees in 1996 to 10 598 employees in 2001.

3.5.2.2 Utilities: Electricity/gas and water

This sector includes the supply (production, collection and distribution) of electricity, gas and hot water. According to a Perception Survey on Service Delivery within the Northern Cape conducted by the Department of Local Government and Housing, 64% of households in the Northern Cape were satisfied with the services provided. It is furthermore also clear from the survey that the bulk of dissatisfied households listed refuse collection and the implementation of sanitation projects as major reasons for frustration.

In contrast to other secondary industries, the utilities sector is the only sector that contracted in real terms, losing 1.1% in value terms between 1990 and 1999. According to StatsSA (2003), the number of persons employed in the utilities sector declined by approximately 11% from 2 432 employees in 1996 to 1 363 employees in 2001.

3.5.2.3 Construction

The construction sector includes the preparation of sites, building of complete constructions or parts thereof, civil engineering, building installation and completion and the renting of construction and demolition equipment to operators. Overall, construction in South Africa is characterised as relatively labour-intensive, consisting of a few large contractors and a mix of medium and small contractors and sub-contractors.

The construction sector is the Northern Cape's smallest economic sector in terms of rand value (R 323.5 million) but showed a 1.5% growth rate between 1990 and 1999. This sector contributes 1.5% towards the national construction GGP. Controversially, employment figures in the construction sector have declined by 2.9%, from 10 404 employees in 1996 to 8 969 employees in 2001.

3.5.3 Tertiary industries

Figure 3.14 shows the provincial contribution towards the GGP of the four tertiary economic sectors, including: i) wholesale and retail trade, hotels and restaurants, ii) trade and communication, iii) finance real estate and business services and iv) community, social and personal services. As in the case of the secondary industries, it is clear that the Northern Cape is the smallest role player, contributing just over 2% towards the national aggregate. On average, the tertiary sector in the Northern Cape grew by 0.6% between 1990 and 1999.

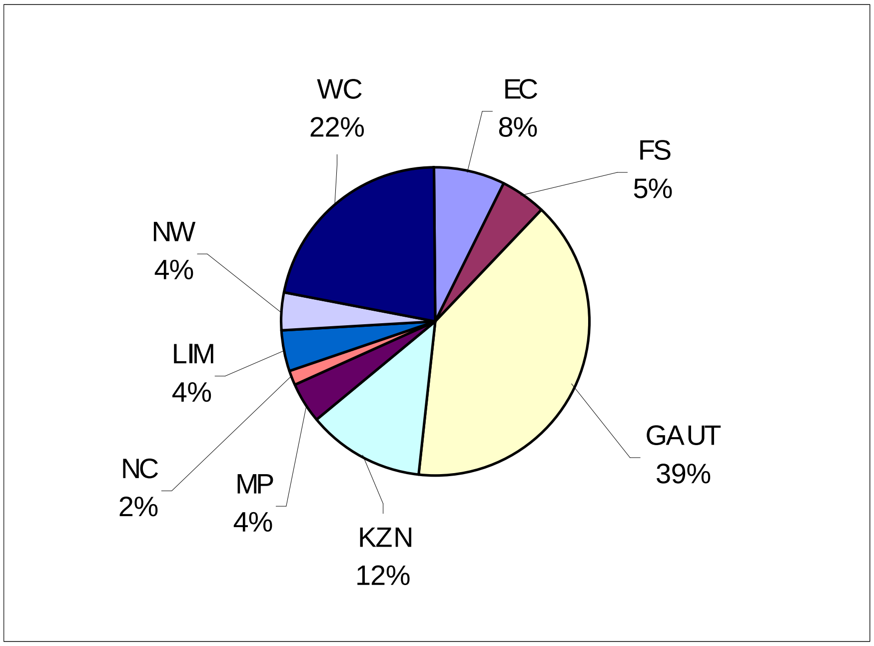


Figure 3.24: Provincial contribution towards the national total tertiary economic sectors (1999)
Source: Du Toit (2001)

3.5.3.1 Wholesale and retail trade; hotels and restaurants

This sector entails wholesale and commission trade, retail trade, repair of personal household goods, the sale, maintenance and repair of motor vehicles and motor cycles, hotels, restaurants, bars, canteens, camping sites and other forms of short-term accommodation.

Trade in South Africa is fast becoming a more dynamic industry, driven by changes in technology, vocal consumerism, saturating markets and globalisation (Du Toit, 2001). During 1999, the wholesale and retail trade sector of the Northern Cape's economy contributed only 1.8% towards the national GGP, representing R 1,7 billion in real value terms. Between 1990 and 1999, this sector grew annually with 1.4% in real terms on average.

In terms of employment, the trade sector experienced a 1.2% growth rate between 1996 and 1999, according to the respective population census estimates. The employment estimates of 24 672 employees working in the trade sector during 2001 represented 11.8% of the total provincial working population.

3.5.3.2 Transport and communication

This sector comprises land, railway, water, and pipelines as well as air transportation services. Activities of travel agencies, post and telecommunications, courier activities and storage are also included in this sector.

The transport and communication sector contributed 2.1% towards the GGP during 1999, representing R 1.5 billion in real value terms. Employment in this sector has seen a dramatic 8.7% decrease in employees between 1996 and 2001. According to estimates, only 3.1% of the provincial workforce was employed in the transport and communication sector during 2001.

3.5.3.3 Finance, real estate and business services

Services such as financial intermediation, insurance, pension funding, real estate activities, renting of transport equipment, computer and related activities, research and development, legal, accounting, bookkeeping and auditing, architectural, engineering and other technical and business activities are included in this sector.

During 1999, the finance, real estate and business services sector contributed a mere 0.9% towards the national sectoral GGP. Although a 1.8% annual decrease in GGP was experienced in this sector between 1990 and 1999, employment figures in this sector increased by 7% between 1996 and 2001.

3.5.3.4 Community, social and other personal services

Public administration, defence, general government activities, education, public and private, health and social work, sewage and refuge disposal, sanitation, washing and dry cleaning of textiles and fur products, hairdressing and other beauty treatment, funeral and related activities are included in this economic sector.

Similarly to the transport sector, the community service sector also contributed a 2.1% towards the national sectoral GGP. Despite the 0.5% growth experienced in this sector between 1990 and 1999, employment figures diminished by 0.7% between 1996 and 2001.

3.6 IRRIGATION WATER AS A SCARCE ECONOMIC COMMODITY IN SOUTH AFRICA

As mentioned and according to DWAF (2004) South Africa is located in a predominantly semi-arid part of the world, with the climate varying from desert and semi-desert in the west to sub-humid along the eastern coastal area. South Africa's water resources are therefore in global terms, scarce and extremely limited. The country has no truly large or navigable rivers, and the combined flow of all the rivers in the country amounts to approximately 49 000 million cubic metres per year (m³/a), less than half of that of the Zambezi River, the closest large river to South Africa (DWAF, 2004).

According to DWAF (2004), the country has been divided into 19 catchment-based water management areas, with the location and boundaries of the different water management areas, as well as inter-water management area transfers shown in Figure 3.25. Of specific importance to this study is the lower Vaal and Orange water management areas.

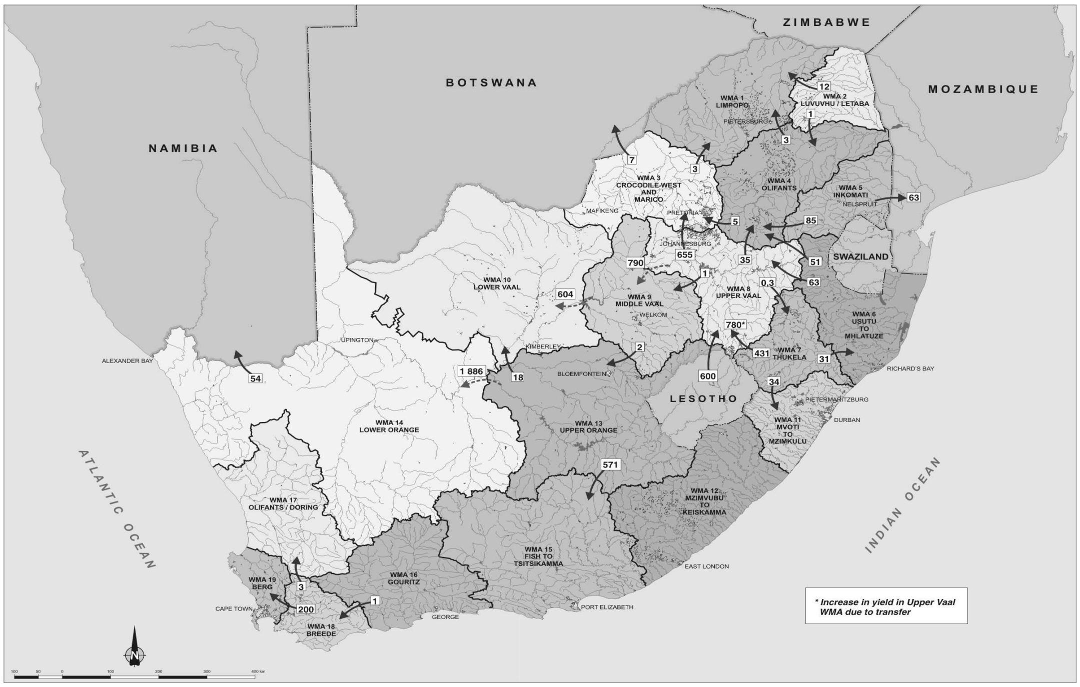


Figure 3.25: Location of water management areas and inter-water management area transfers
Source: DWAF (2004)

DWAF (2004) provides a graphical comparison of the natural occurrence of water, the population and the economic activity (GDP) per Water Management Area (WAMA) as shown in Figure 3.26 which clearly demonstrates the exceedingly varied conditions among the water management areas. The Crocodile West and Marico water management area for example, where the largest proportional contribution to GDP is produced, is one of the management areas with the smallest mean annual runoff. In contrast, the economic contribution as well as the population of the upper Orange water management area for example is slightly over 5%, whereas the mean annual runoff is approximately 14% of the national total. The lower Orange water management area (i.e. located in the NCP), despite being low in relative contribution to the national total, is one of the most balanced areas in terms of the mean annual runoff, population and economic contribution, with all three being around 0.85%.

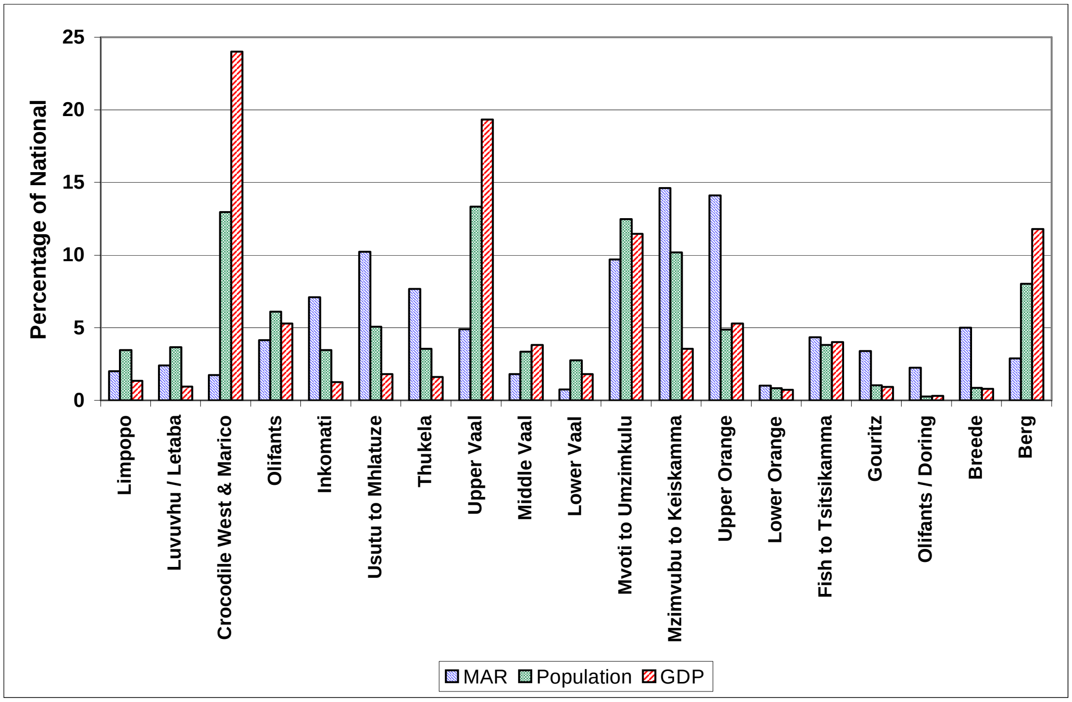


Figure 3.26: Comparison of the mean annual runoff (MAR), population and economic activity (GDP) per water management area
Source: DWAF (2004)

The water requirements as published by DWAF (2004) are reported in Table 3.4. From the Table it is clear that during 2000, agriculture utilized 62% of the national resource for irrigation. The second largest user of water is urban households (23%) followed by mining and bulk industrial (8%) whereas rural households, power generation and afforestation consumes combined only 9%.

In terms of the WMA's, the lower Orange (part of the NCP) irrigates the lion's share with 12.3% of the national total irrigation, followed by the upper Orange (9.8%) and the Fish to Tsitsikamma (9.6%). Combined the lower Vaal and Orange WMA's has nearly 20% of the national available irrigation water and thereby again shows the relative importance of the NCP in term of national irrigation resources.

Table 3.4: Water requirements for the year 2000 (million m³/a)

WMA	Irrigation: million m^3/a	Irrigation: % of national irrigation	Urban	Rural	Mining and bulk industrial (2)	Power generation	Afforestation	Total local requirements
Limpopo	238	3.0%	34	28	14	7	1	322
Luvuvhu/ Letaba	248	3.1%	10	31	1	0	43	333
Crocodile West and Marico	445	5.6%	547	37	127	28	0	1 184
Olifants	557	7.0%	88	44	94	181	3	967
Inkomati	593	7.5%	63	26	24	0	138	844
Usutu to Mhlathuze	432	5.5%	50	40	91	0	104	717
Thukela	204	2.6%	52	31	46	1	0	334
Upper Vaal	114	1.4%	635	43	173	80	0	1 045
Middle Vaal	159	2.0%	93	32	85	0	0	369
Lower Vaal	525	6.6%	68	44	6	0	0	643
Mvoti to Umzimkulu	207	2.6%	408	44	74	0	65	798
Mzimvubu to Keiskamma	190	2.4%	99	39	0	0	46	374
Upper Orange	780	9.8%	126	60	2	0	0	968
Lower Orange	977	12.3%	25	17	9	0	0	1 028
Fish to Tsitsikamma	763	9.6%	112	16	0	0	7	898
Gouritz	254	3.2%	52	11	6	0	14	337
Olifants/Doring	356	4.5%	7	6	3	0	1	373
Breede	577	7.3%	39	11	0	0	6	633
Berg	301	3.8%	389	14	0	0	0	704
RSA total	**7920**	**100%**	**2 897**	**574**	**755**	**297**	**428**	**12 871**
National share	**62%**		**23%**	**4%**	**6%**	**2%**	**3%**	**100%**

Source: DWAF (2004)

3.7 CURRENT WATER REGULATION IN SOUTH AFRICA

With water policy in the Republic of South Africa being more that 130 years old, Backeberg (2005) explains that "ever since the start of an active irrigation policy in the Cape Colony of South Africa in 1875, major policy and institutional changes have been prompted by a combination of political, economic, social and natural events in the country". Backeberg (2005) (quoting Backeberg, 1994 and Bate and Tren, 2002) also explains that major policy reforms were preceded by either extended drought periods, political changes (i.e. 1910, 1948 as well as 1994), development related factors (such as industrialization and urbanization) or social and equity factors (i.e. provision of water to the disadvantaged and poor communities).

The SA water sector can currently be described as being in the maturing phase, with increasing water demand, intensive competition among uses and users, rehabilitation requirements of existing infrastructure, extreme externalities resulting from water pollution and the high social cost attached to subsidization of increased water supply (Randall, 1983; Backeberg and Groenewald, 1991 as in Backeberg, 2005).

Water in SA is essentially regulated and enforced by the Water Law Principals (1996), the National Water Policy (1997), the National Water Act (Act 36 of 1998). The Water Act called, as legal requirement, for the development of an implementation strategy which was developed and published by the DWAF (2004) as the National Water Resource Strategy (NWRS). The Policy and Act are based on three principals, i.e. equity, sustainability and efficiency and the NWRS was developed to implement these water regulations, in that it describes the policies, strategies, plans and procedures by which the nation's needs for water, jobs and economic growth can be met. The National Water Policy, Act and Strategy are described in more detail in the following three sub-sections respectively. More specifically, four principal challenges of irrigation policy include: the rehabilitation of existing irrigation schemes, determination of the development capacity of new irrigation, establishment of effective policy implementation organizations as well as increased efficiency of water use.

3.7.1 The Water Policy

Since 1994, government policy in South Africa has focused strongly on equitable and sustainable social and economic development for the benefit of all South Africa's people. The South African National Water Policy (NWP) is based on 28 fundamental principles and objectives for a New South African Water Law (DWAF, 2002), covering:

- Legal aspects (4 principals),
- the water cycle (2),
- water resource management priorities (5),
- water resource management approaches (10),
- water institutions (3), and
- water services (4)

As mentioned above, three equal important objectives (guiding the water law are firmly grounded in the provisions of the Bill of Rights of the Constitution of South Africa of 1996, i.e. No. 108 of 1996) arise from the Principles, including (DWAF, 2002):

- **Equitable access** to water - equity of access to water services, to the use of water resources, and to the benefits from the use of water resources.
- **Sustainable use** of water - progressive adjustments to water use with the objective of striking a balance between water availability and legitimate water requirements, and by implementing measures to protect water resources.
- **Efficient and effective water use** - for optimum social and economic benefit.

This basically implies that despite inequalities of the past that must be corrected, the water policy (importantly) realises that this transformation must come to pass firstly in a sustainable manner and secondly in a way that will ensure the most optimum (i.e. the best for society as a whole) use of the resource available.

3.7.2 The Water Act

DWAF (2002) explicate that the National Water Act (NWA), 1998 (No. 36 of 1998) derives directly from the "Fundamental Principles and Objectives for a New South African Water Law and the NWP's proposals for managing water resources" and therefore contains the legal provisions that enable the proposals in the NWP to be implemented. It is realised in the NWA that the successful management of water resources depends on co-operation among all spheres of government, and the active involvement of water users and other organisations and stakeholders (DWAF, 2002).

According to DWAF (2002) an important provision in the NWA, which is key to the achievement of Policy objectives, is the establishment by National Government, acting through the Minister of Water Affairs and Forestry, as the public trustee of the nation's water resources. Where *"public trusteeship does not mean that government owns the water, since the Preamble to the Act recognises that "water is a natural resource that belongs to all people", but it does mean that the Minister has overall responsibility and, importantly, the authority to ensure that all water everywhere in the country is managed for the benefit of all persons."*

The main purpose of the NWA is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways which take into account amongst other factors (DWAF, 2002):

- meeting the basic human needs of present and future generations (i.e. sustainable);
- promoting equitable access to water; redressing the results of past racial and gender discrimination;
- promoting the efficient, sustainable and beneficial use of water in the public interest;
- facilitating social and economic development;
- providing for growing demand for water use;
- protecting aquatic and associated ecosystems and their biological diversity;
- reducing and preventing pollution and degradation of water resources;
- meeting international obligations;
- promoting dam safety; and
- management of floods and droughts.

It therefore calls for the establishment of suitable institutions and to ensure that they have appropriate community, racial and gender representation.

3.7.3 The National Water Resource Strategy

As mentioned above, the NWA requires the NWRS to "*set out the strategies, objectives, plans guidelines and procedures of the Minister and institutional arrangements relating to the protection, use, development, conservation, management and control of water resources."*

The purpose of the NWRS is basically fourfold in nature, including the provision of:

i. A management framework for water resources,
ii. Catchment management strategies,
iii. Information provision, and
iv. Development opportunities and constraints identification.

The NWRS further proposes eight possible reconciliation interventions by which a balance between the availability of and requirements for water may be achieved, including: demand management, water resource management, management of groundwater resources, re-use of water, control of invasive alien vegetation, re-allocation of water, development of surface water resources and well as inter-catchment transfers. Some of these interventions and the linkage thereof with the effective use of water are discussed in more detail in the following section.
According to DWAF (2002), irrigation agriculture accounts for about 62 per cent of water used in South Africa, of which many areas use irrigation water highly efficiently. However, the NWRS explains that there are significant losses in many distribution and irrigation systems, whilst substantial improvements can be achieved in others. Efficiency gains in the sector will therefore make water available for the national water reserve and therefore also for other uses. The strategy designed by the NWRS to improve irrigation efficiency includes a framework of regulatory support and incentives. In line with the overall objectives it promotes the "equitable and efficient use of water in the sector in order to increase productivity and contribute to reducing income inequalities among people supported by farming activities". The framework defined by the NWRS briefly described key areas as follows:

- Reduction in water wastage;
- progressively modernise their water conveyance systems and irrigation equipment;
- Water allocation processes to promote the equitable and optimal utilisation of water;
- Preventive maintenance programmes;
- Sufficient irrigation information is generated and is accessible to all stakeholders; and
- Water management institutions and service providers implement audits from the water source to end users and beyond.

3.8 SUMMARY

In this chapter, the provincial economy of the NC was discussed and put into perspective relative to the broader national economy. Due to the fact that this study focuses primarily on irrigated agriculture in the NCP, more attention were given to agricultural production, demographics in the NCP as well as the national water situation in the different WMA's. The current water regulations in South Africa, with specific reference to effective water use, were also discussed.

Even though the NCP occupies over 30% of the total RSA area (i.e. largest province), the economy (only 2.4% of the national GDP) and population (only 2% of the national population) thereof are considered the smallest of all provinces. The NCP is also one of the most urbanized provinces, despite its vast area, with more than 70% of its households living in urban areas. In term of water available for irrigation, the NCP has access to nearly a quarter of this vital important resource.

Agriculture in the NCP contributes approximately four times more (16%) towards the GGP compared to the national average of around 4%. In terms of irrigation agriculture, the WMA in the NCP, i.e. the upper and lower Orange as well as the lower Vaal uses nearly 29% of the national available irrigation water. This is however, not exclusively limited to the NCP, but mainly represents the WMA that provides irrigation water to the NCP.

CHAPTER 4

DEVELOPMENT OF THE ECONOMIC-WIDE MODELLING FRAMEWORK

Table of contents:

4.1 INTRODUCTION....97
4.2 THE PROVIDE SAM....98
4.2.1 Adjustments made to the original SAM 98
4.3 ECONOMIC MULTIPLIERS FOR THE NCP 99
4.3.1 SAM Leontief multipliers.... 101
4.4 THE CGE MODEL FOR THE NCP....103
4.4.1 Activities, production and factor markets 105
4.4.2 Institutions.... 106
4.4.3. Commodity markets 106
4.4.4 Macroeconomic balances/closure rules.... 107
4.4.4.1 The external closure.... 108
4.4.4.2 The savings-investment closure 108
4.4.4.3 The government closure.... 109
4.4.4.4 Factor market closures 109
4.4.4.5 Choice of closure combinations.... 110
4.4.4 Model code.... 110
4.5 LINKAGES BETWEEN MACRO AND MICRO MODELS 111
4.5.1 Micro-macro linkages (Bottom up) 111
4.5.2 Macro-micro linkages (Top down).... 113
4.6 CONCLUSION 113

List of figures:

FIGURE 4.1: SCHEMATIC PRESENTATION OF THE PRODUCTION TECHNOLOGY IN A CGE MODEL ____ 105
FIGURE 4.2: SCHEMATIC PRESENTATION OF THE FLOWS OF MARKETED COMMODITIES ____ 107
FIGURE 4.3: MICRO-MACRO LINKS ____ 112

CHAPTER 4

DEVELOPMENT OF THE ECONOMY-WIDE MODELLING FRAMEWORK

*In economy-wide studies, SAM's and Computable General-Equilibrium (CGE) models have become important analytical workhorses. (*Tarp *et al., 2002)*

4.1 INTRODUCTION

At the micro level, the "farm model" captures the farmer's decision-making in production activities whereas the **macro model** (typically in a CGE framework) is designed with the purpose to capture the multi dimensions of the decision-making process in the larger economy. For this reason Diao *et al.* (2004) show that prices, including prices for output and factor markets, are endogenously determined by the macro model, which can typically be done in CGE format.

McDonald and Punt (2005) explain that many international agencies, including the World Bank, the International Monetary Fund (IMF) and the World Trade Organization (WTO), as well as various national governments, use CGE models on a frequent basis in analysing a variety of policy issues, including:

- structural adjustment programmes,
- trade policy reform,
- fiscal/taxation policies,
- environmental policies (especially carbon emissions),
- sectoral policies (especially those relating to agriculture),
- income distribution implications of economic policies,
- etc.

In the next section, a description of the SAM used as a database is provided, followed by an overview of the adjusted IFPRI standard CGE model used as economic-wide model. The chapter is then concluded with some remarks on the rationale and comparability of the modelling framework applied.

4.2 THE PROVIDE SAM

As funders of the PROVIDE project, the National and Provincial Departments of Agriculture in South Africa developed a series of SAM's for the 2000 base year (PROVIDE, 2006). The national SAM, with disaggregated detail specifically for agricultural activities in the Northern Cape Province (NCP) of South Africa, was used as the database for the CGE model. More specifically, the version of the SAM used in this analysis included commodity accounts (52, of which 16 are for agriculture), transaction accounts (3), activity accounts (56, of which 20 are for agriculture including 8 for NCP agricultural activities), factor accounts (46), institutional accounts (45), capital accounts (2) and an account for the rest of the world. An aggregated version of the PROVIDE SAM, for the 2000 base year, is shown in Appendix 4A at the end of this document for reference purposes.

The commodity and activity accounts in the PROVIDE SAM are largely based upon the account classification scheme used in the supply and use tables for South Africa published by Statistics South Africa. The household categories, on the one hand, are identified first by province of residence, then population group and then by other selected criteria such as gender and education level of head of household. Factor categories for land and labour, on the other hand, are identified by province. The labour categories are further distinguished by population group and skill level (PROVIDE, 2006). The following commodity taxes are included in the SAM:

- Value-added tax on domestic goods and services,
- Value-added tax on imported goods and services,
- Excise duties and
- Import duties.

Activity taxes include production taxes and value-added tax refunds. The agricultural commodity accounts reflect the pattern of commodity production in South Africa, while the agricultural activity accounts classify farms by regions (magisterial districts) within provinces. These agricultural activity accounts represent agronomic regions that produce a combination of agricultural commodities and can therefore be viewed as multi-product firms. The agricultural regions for purposes of the SAM are consistent with statistical regions for which data are available in the Agricultural Census of 1993 (PROVIDE, 2006). Interested readers are referred to PROVIDE (2006) for a detailed discussion on the compilation and contents of the PROVIDE SAM used in this study.

4.2.1 Adjustments made to the original SAM

A few adjustments were made to the original PROVIDE SAM in order to render the SAM compatible with the CGE model used, including adjustments to the following accounts: transaction costs (trade and transport margin), business enterprises and savings accounts, and the various tax accounts. Transaction costs in the original PROVIDE SAM are divided between trade and transport margins respectively. The IFPRI standard CGE model also associates trade flows with transaction costs or marketing margins but distinguishes between domestic, import and export marketing. The marketing margin of domestically produced output represents the cost of moving the commodity from the producer to the domestic consumer. For imports, it represents the cost of moving the commodity from the border (adding to the c.i.f. price) to the domestic consumer, while for exports, it shows the costs of moving the commodity from the producer to the border (Lofgren *et al.,* 2002). The trade and transport margins from the original PROVIDE SAM were therefore allocated between transaction costs for domestic, import and export marketing in order to fit the CGE model requirements. This was done by allocating the total transaction cost (trade and transport margins) proportionally to the values of domestic sales of domestically produced commodities, imported commodities and exported commodities.

The accounts for business enterprises and savings are treated slightly differently for the purpose of the CGE model than originally specified in the PROVIDE SAM. In the PROVIDE SAM, the savings of factors (depreciation) that accounts for gross operating surplus (GOS) are shown directly, whereas in the adjusted SAM, these savings are first directed to the business enterprise before being transferred back to the savings account. The logic behind this is that a share of the profits made by business enterprises are saved, then later reinvested and therefore spent on commodities.

Tax accounts in the original PROVIDE SAM included import duties, value-added tax (on imports and domestic goods and services), excise duties, sales subsidies, production taxes, production refunds, production subsidies, direct income taxes and an account for the general government. Adjustments to the tax accounts for the purpose of calibration to the CGE model were basically limited to the aggregation of some of the tax accounts. Value-added taxes on imports and domestic goods and services, excise duties and sales subsidies were aggregated into one account for net sales taxes, whereas production taxes, production refunds and production subsidies were aggregated into one account for net industry taxes. A list of all account abbreviations together with descriptions of the adjusted SAM is provided in Appendix 4B.

4.3 ECONOMIC MULTIPLIERS FOR THE NCP

As explained in Chapter 2, economic multipliers measure the nature and extent of the impact or effect of an autonomous change/shock in a specific economic (i.e. exports) quantity on other economic quantities (i.e. employment of production).

According to McDonald and Punt (2004), more sophisticated models, such as CGE models for example, also have additional data requirements, which is why simpler fixed-price models (such as SAM multiplier models) still remain widely used. Pyatt (1988) explains that multipliers show

how an economy operates, given a certain set of assumptions, which should therefore be interpreted within the appropriate context. He therefore warns that multipliers should be interpreted as the results from counterfactual conditional experiments.

Despite the advantages listed above, with regard to the CGE over and above a simple multiplier analysis from an I/O table or a SAM, it is recommended that a multiplier (impact) analysis is conducted before the CGE model is built. The reason for this, according to Van Seventer (2005), is that conducting a multiplier analysis before doing a CGE model helps in better understanding and explaining the economy of the specific region. Keeping in mind that the linkage between the macro and micro model will only be done in the CGE framework, multipliers obtained from an impact analysis conducted from the Northern Cape SAM will provide initial indicators of the magnitude of the multiplier effects of irrigation agriculture in the province.

Two key assumptions made by typical SAM-Leontief multiplier models, includes first, fixed relative prices are assumed, and secondly, perfect elastic supply conditions, i.e. excess production capacity in all sectors. Sadoulet and de Janvry (1995) explain that these assumptions lead to the central assumption in this type of analysis that sectoral production is completely demand driven and that the underlying production function assumes constant returns to scale and no substitution among the different inputs.

According to McDonald and Punt (2004), it is therefore clear that a SAM multiplier framework cannot reflect interactions in a market economy in which price adjustments play an important role and where important substitution possibilities in both the production and demand exist. Multiplier analysis is therefore not suitable to study shocks that relate to structural changes based on relative price changes such as real exchange rate movements, wage repression or terms-of-trade effects. To capture these features, a non-linear model with joint determination of prices and quantities, such as a computable general equilibrium (CGE) model, must be used (McDonald and Punt, 2004). Multiplier models can, however, be used to provide rough first approximations of outcomes. They further also point out that these approximations will tend to be better for cases where imposed changes or shocks are relatively small or where relative prices are not expected to change substantially.

Despite these shortcomings, in order to estimate the macro-economic impact of simulated changes at farm (micro-economic) level, three sets of economic multiplies are calculated (see Chapter 6 for description of results and impacts) from an aggregated version of the NCP SAM. For the purpose of calculating the multipliers, various accounts in the original version of the SAM described above were aggregated. In terms of commodity accounts, all non-agricultural commodities were aggregated, whereas all activities except for the agricultural activities in the NCP were aggregated. The same was done in terms of production factor accounts and households, where all accounts except for the NCP labour factors and NC households were aggregated. This aggregated SAM version, consisting of 35 accounts in total (7 commodities, 9 production activities, 8 factors of production, 6 household groups, a margin account, a government account, a capital account and a rest-of-the-world account) was then used to calculate labour, income, capital and value-added multipliers.

4.3.1 SAM Leontief multipliers

Given the assumptions listed in the previous section together with the characteristics of a SAM, as provided in Chapter 2, two matrices derived from a SAM can be used as instruments for economic analysis, namely the technical input coefficient matrix and the Leontief inverse matrix (or multiplier matrix). Equation 1 shows that a technical coefficient (a_{ij}) is defined as the quantity of intermediate inputs from sector i required by a sector j to supply a unit of output from sector j (all measured in monetary terms).

$$a_{ij} = \frac{X_{ij}}{X_j} \qquad \text{(i=1,……,n) and (j=1,…….,n)} \tag{1}$$

Where:

a_{ij} is a technical production coefficient indicating the amount of products from Sector i needed to produce one unit of product in Sector j (technical coefficient);

X_{ij} is the delivery of intermediate goods from sectors i to sector j;

X_j is total gross input (output) of sector j.

The following holds for specific elements in a transaction table:

$$a_{11} = \frac{X_{11}}{X_1}; \quad a_{12} = \frac{X_{12}}{X_2}; \text{ …and } \quad a_{1n} = \frac{X_{1n}}{X_n}$$

The technical coefficients matrix is a collection of technical coefficients and is often indicated by a capital letter “A”:

$$A_{ij}\begin{bmatrix} a_{11} & a_{12} & . & . & . & a_{1n} \\ a_{21} & a_{22} & & & & a_{2n} \\ . & & & & & . \\ . & & & & & . \\ . & & & & & . \\ a_{n1} & a_{11} & & & & a_{nn} \end{bmatrix} \qquad \text{Where (i= 1,. . . , n) and (j= 1,. . ., n)}$$

The output needed to satisfy a given level of gross output is shown by equation 2:

$$O = A \times X \tag{2}$$

Where:

X denotes a vector of activity levels (in value terms) in an economy;

A denotes the amounts of each activity used by every other activity at rates assumed to be independent of the levels of activity in X (constant returns to scale); and

O is a vector containing the intermediate demand for its outputs and the total final demand for its inputs.

Total activity X satisfies endogenous (AX) and exogenous (D) uses. If A is assumed to be parametric, any change in D must be accommodated by a corresponding change in X (see equation 3).

$$X = AX + D \tag{3}$$

Solving for X, the relationship between D and activity vector X is shown in equation 4:

$$(A \times X) + D = X \text{ and } D = X - (A \times X) \tag{4}$$

Rearrangement of the above equation yields (equation 5):

$$D = (I - A) \times X \tag{5}$$

Thus,

$$X = (I - A)^{-1} \times D \tag{6}$$

Where $(I - A)^{-1}$ as shown in equation 6, it is known as the multiplier matrix or Leontief inverse. As explained in the previous section, four sets of economic multipliers are calculated in this study, including GDP or value-added multipliers, labour, capital and income, which are all calculated and expressed in terms total activity production as shown in equation 7 to 10 in a manner similar to the method explained and used by Conningarth (2005).

$$Value\ added = \frac{Value\ added}{production} \tag{7}$$

Where value added or GDP is measured as the total value that is added to each product produced by the various activities. According to Conningarth (2005), value added for a specific sector is calculated as the difference between the revenue the sector earns and the amount it pays for the products of other sectors it uses as intermediate goods. As such, value added can be calculated from a SAM as the sum of:

- Remuneration of employees
- Gross operating surplus (which includes, amongst others, profits and depreciation)
- Net indirect taxes

$$Labour = \frac{Employment(numbers)}{production} \tag{8}$$

As indicated by equation 8, the labour or employment multipliers indicate the extent to which economic sectors contribute to job creation. This is intimately an indication of each sector's contribution towards distributing salaries and wages between various types of labourers, which, in turn, should impact positively on the alleviation of poverty (Conningarth, 2005).

$$\Pr oduction = \frac{\Pr oduction}{production} \tag{9}$$

Conningarth (2005) explains that that in economics, production measures the total turnover generated by each sector in the economy. Production is therefore the sum of the demand for intermediate activities as well as the total value added by the specific activity. The formula for calculating the production multiplier is shown in equation 9. The direct production multiplier therefore equals 1.

For all three multipliers listed, the total effects consisting of the direct, indirect and induced effects are calculated and reported in Chapter 6 for agricultural activities in the NCP. These total multiplier effects are then used to determine the likely impacts of simulated changes at micro-economic (farm level), which was reported on in the first phase of the project (see Louw *et al.*, 2007).

4.4 THE CGE MODEL FOR THE NCP

In essence, a CGE model explains all entries (payments) in the database or SAM. It is therefore typical that a CGE model follows the desegregation of factors, activities, commodities and institutions. A set of simultaneous equations, many of which are in non-linear form, is used to simulate/define the different actors of an economy. In contrast to other economic models, a CGE typically does not make use of an objective function.

Löfgren *et al.* (2002) explain that production and consumption decisions are driven by the maximisation of producer profits and consumption utility, respectively. Amongst the equations is a set of constraints to be satisfied by the system as a whole and not necessarily by any individual actor. These constraints cover markets (factors and commodities) and macro-economic aggregates (balances for savings/investments, the government and the current account for the rest of the world).

The IFPRI-standard CGE model follows the neoclassical-structuralist format and thereby explains all payments recorded in the SAM used as database, where neoclassical economics refers to a general economic approach focusing on individual and group choice based on preference relations. The neoclassical economic school of thought typically involves rational utility or profit maximisation using available information (www.wikipedia.org, 2006b). According to www.wikipedia.org (2006b) mainstream economics can largely be classified as neoclassical in nature and is often also known as the marginalist school.

Löfgren *et al.* (2002:iv) further explain that the IFPRI model developed over years of research by a team of researchers incorporates features specifically important in developing countries, including household consumption of non-marketable commodities, the explicit treatment of transaction costs for commodities entering the market sphere, and the separation of production activities and commodities that permits any activity to produce multiple commodities and any commodity to be produced by multiple activities.

From the description of the IFPRI model above, it is clear that many advantages, including not having to "reinvent the wheel", arise from adopting the standard IFPRI CGE model for purposes of analysis of the macro-economic phase of this project. It was therefore decided that the standard IFPRI model would be adopted where required for macro-economic analysis purposes

When considering a bird's eye view of a CGE model, four components can be identified: 1) activities, production and factor markets, 2) institutions, 3) commodity markets, and 4) macro balances or closure rules. In the remainder of this section, each of these components is briefly discussed, mainly following the approach used by Löfgren *et al.* (2002). Chapter 4 contains, amongst other things, a more detailed discussion of the model.

The IFPRI model is written to follow the desegregation of activities, commodities, factors and institutions distinguished in the SAM. Unlike other mathematical programming models, a CGE model has no objective function but utilises the equations specified to define the behaviour of the different actors in the economy (Lofgren *et al.,* 2002). For example, production and consumption behaviour decisions are typically captured by nonlinear first-order optimality conditions. By using these first-order optimality conditions, profits and utility are maximised for production and consumption respectively. In addition to these production and consumption equations, a set of constraints that have to be satisfied for the system as a whole are specified. These constraints include:

- market constraints (for all factors and commodities) and
- macro-economic aggregates (savings-investment, government, current account and the rest of the world).

The basic characteristics of the CGE model can be grouped into four segments (as explained in Chapter 2) including: 1) activities, production and factor markets, 2) institutions, 3) commodity markets and 4) macro balances or closure rules. In the remainder of this section, each of these components is briefly discussed mainly following the approach used by Lofgren *et al.* (2002).

4.4.1 Activities, production and factor markets

As mentioned, producers (represented by activities) are assumed to maximise profits, subject to production technology as shown in Figure 4.1. Value added to primary factors of production is usually specified as a constant elasticity of substitution (CES) function. The aggregate intermediate inputs are usually specified as a Leontief function of disaggregated intermediate inputs. Activities that produce commodity outputs, reflected at the top level in Figure 4.1, can either be specified as a Leontief function or as a CES function. The standard IFPRI model typically uses the Leontief as default, but the CES alternative may be preferable for particular sectors where available techniques permit the aggregate mix between value-added and intermediate inputs to vary (Lofgren *et al.,* 2002).

Each activity produces one or more commodities, but a commodity can also be produced by more than one activity. Activity revenue is therefore a function of activity level, yields and commodity prices at production level. In the production process, a combination of production factors (capital, land and labour) are used by the activities up to the profit maximisation point, i.e. where the marginal revenue product equates to the wage/price/rent of the factor. A factor wage may differ across activities for segmented markets and mobile factors (Lofgren *et al.,* 2002). In the case of factors supply, fixed supplies are normally specified.

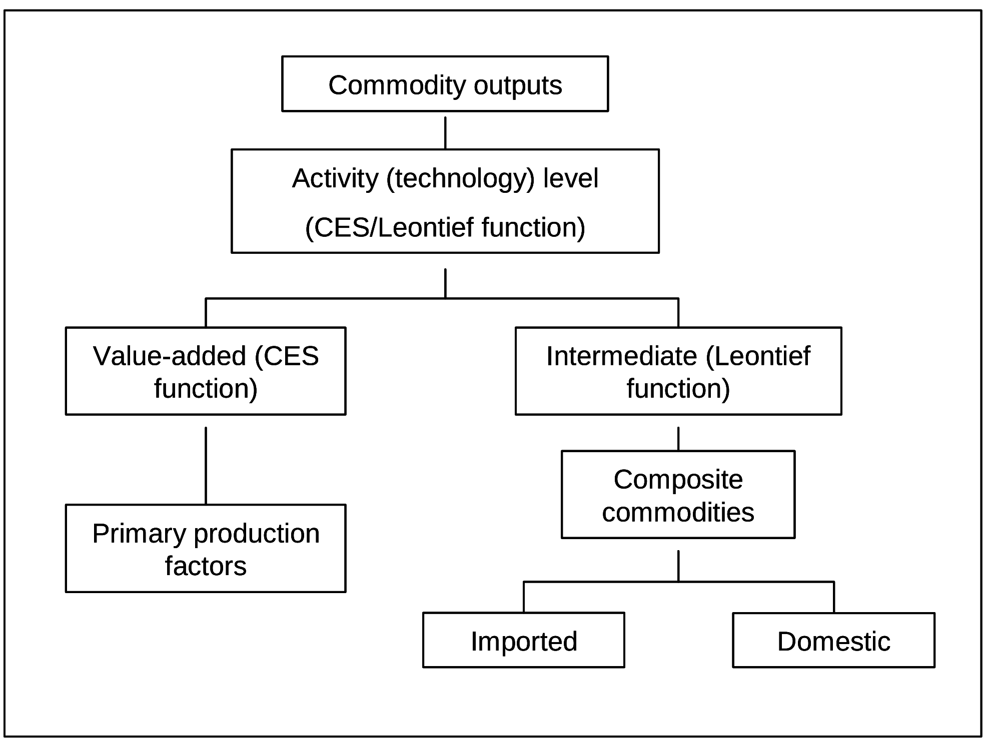


Figure 4.1: Schematic presentation of the production technology in a CGE model
Source: Adapted from Lofgren et al. (2002)

4.4.2 Institutions

Institutions in the CGE model refer to households, enterprises, government and the rest of the world. **Households** receive income from factors of production as well as transfers from other institutions and the rest of the world (fixed in foreign currency). Household expenditure is allocated among consumption, taxes, savings and transfers to other institutions. Household consumption in the PROVIDE SAM only covers marketed commodities, which are purchased at market prices and therefore include commodity taxes and transaction costs as well as home commodities. The CGE model exploits a linear expenditure system (LES) demand function (which is derived from maximising a Stone-Geary utility function) for the allocation of household consumption across different commodities.

In addition to incomes paid to households, factor incomes are also paid to one or more enterprises. Enterprises further also receive transfers from other institutions, whereas enterprise incomes are allocated to direct taxes, savings and transfers to other institutions (Lofgren *et al.,* 2002). In contrast to households, institutions do not consume.

Government receives income from the taxes it collects as well as transfers from institutions. On the expenditure side, government uses its income to purchase commodities for its consumption and for transfers to other institutions. Government savings, the difference between government income and spending, is usually treated as a flexible residual.
In contrast to all the other institutions listed above, transfers and payments between the rest of the word (RoW) and domestic institutions and factors are all fixed in foreign currency (Lofgren *et al.,* 2002). Foreign savings (or the current account deficit) is the difference between foreign currency spending and receipts.

4.4.3. Commodity markets

All commodities produced in an economy (as reported in the PROVIDE SAM), except home-consumed output, enter markets. Aggregate domestic output is represented mathematically by means of a constant elasticity of substitution (CES) function from the outputs of individual activity outputs. These outputs are imperfectly substitutable as a result of, for example, timing, quality and distance between the locations of activities. Lofgren *et al.* (2002) explain that in the next stage, aggregate domestic output is allocated between exports and domestic sales on the assumption that suppliers maximise sales revenue for any given aggregate output level, subject to imperfect transformability between exports and domestic sales, expressed by a constant elasticity of transformation (CET) function. It is furthermore assumed that in terms of international markets, exports are infinitely elastic at given world prices.

Domestic demand is seen as the aggregate of household consumption, government consumption, investments and intermediate input use. To the extent that a commodity is imported, all domestic market demand is for a composite commodity made up of imports and domestic output. These demands, which are derived on the assumption that domestic demanders minimise cost subjected to imperfect substitutability, are captured by a CES aggregation function, also known as an Armington function. In the case where a specific commodity is not produced locally, total market demand is directed to imports, whereas domestic output supplies total market demand in the case of non-imported commodities.

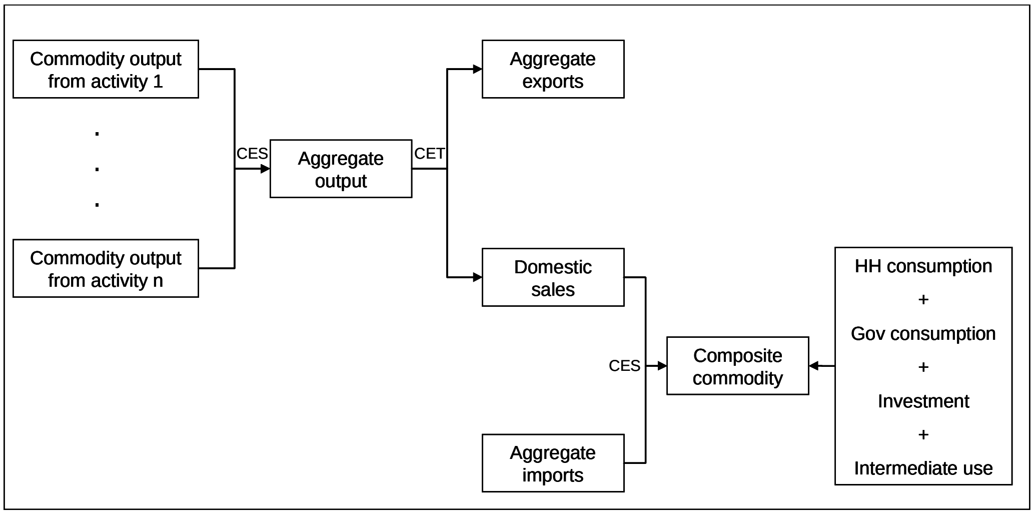


Figure 4.2: Schematic presentation of the flows of marketed commodities
Source: Adapted from Lofgren et al. (2002)

Robinson and Lofgren (2005) explain that the supply and demand equations in a CGE model are all homogeneous of degree zero in prices, meaning that if all prices in the model are doubled, the equilibrium production and demand levels do not change. In macro-economic terminology, this is referred to as the absence of money illusion or the neutrality of money. It implies that doubling the money supply will double all prices without any change in simulated real quantities in production, consumption or trade. A key feature of a CGE model is that it can only determine relative prices, making it necessary to choose some price or price index to define a numéraire that anchors the absolute price level (Robinson and Lofgren, 2005).

4.4.4 Macroeconomic balances/closure rules

The macroeconomic balances or closure rules form the mechanism by which equilibrium is achieved in a CGE model. Similarly to other open, economy-wide models, the standard IFPRI CGE model inevitably includes three macro balances. Robinson and Lofgren (2005) explain that each combination of assumptions regarding how institutions equilibrate effectively imposes a macro-economic story on the CGE model. Likewise, these closure rules or assumptions can substantially influence model results (Provide, 2005b).

The specification of the macro closures of the CGE model forms an essential part of the process of adapting a real CGE model for macro analysis. The three macro-economic balances used in the CGE model include the foreign trade and current account (external or ROWCLOS), the savings investment balance (SICLOS) and the government balance (GOVCLOS). The standard IFPRI CGE model includes a number of pre-programmed alternative closure rules for the macro-economic balances.

4.4.4.1 The external closure

In terms of the external balance, Robinson and Lofgren (2005) state that there is broad consensus on the general outline of an open economy CGE model. Open economy models incorporate imperfect substitutability between domestically produced and imported goods by means of an Armington demand function. Today, most open-economy CGE models allocate domestic demand across imports and domestic outputs on the basis of CES functions and domestic output across exports and domestic supply by means of sectoral CET functions. The default external closure (ROWCLOS1) in this CGE model, which is expressed in foreign currency units, is specified with a flexible exchange rate, while foreign savings (or current account deficit) are fixed. Lofgren *et al.* (2002) explain that since all other items are fixed in the external balance (transfers between the ROW and other institutions), the trade balance is also fixed. The alternative closure for the external balance (ROWCLOS2) uses a fixed exchange rate, while foreign savings (and trade balance) are flexible.

4.4.4.2 The savings-investment closure

In terms of the savings-investment (S-I) balance, 5 alternatives are programmed in the Standard IFPRI CGE model and are either investment-driven (the value of savings adjust) or savings-driven (where the value of investment adjusts) (Lofgren *et al.,* 2002). As default closure (SICLOS1), a fixed savings rate for households and scale investment demand is utilised so that investment spending equals the value of savings. According to Robinson and Lofgren (2005:274), this is normally referred to as neoclassical S-I closure. In addition to the default, the following four additional closures are specified:

- SICLOS2 is also investment-driven but differs from the default in that the base year savings rate for selected institutions is scaled.
- The second alternative (SICLOS3) is savings-driven, with fixed savings rates for all nongovernmental savings.
- Alternative three (SICLOS4) is a variant of the investment-driven closures, where the savings rates of selected institutions are adjusted by an equal number of percentage points compared with SICLOS2.

- For the final alternative (SICLOS5), the savings rates of selected institutions are scaled in order to generate enough savings for finance investments.

4.4.4.3 The government closure

The third balance, the government balance, assumed in the CGE model that the government collects taxes, makes and receives transfer payments, and purchases goods and services. For all three government closures specified, government consumption is fixed, either in real terms or as a share of nominal absorption. The default government closure (GOVCLOS1) government savings are determined residually as the gap between revenue and expenditure, and are therefore flexible. In the case of the first alternative (GOVCLOS2), the base year direct tax rates of domestic nongovernmental institutions (households and enterprises) are endogenously adjusted by the same number of percentage points. In contrast, the second alternative (GOVCLOS3) multiplies the tax rates of selected institutions by a flexible scalar.

4.4.4.4 Factor market closures

The simulation file of the standard IFPRI model includes three factor market closures, i.e. the mechanisms for equilibrating factor market demands and supplies. The factor closures differ in terms of factor employment as well as factor mobility.

The first and typical default factor closure assumes full factor employment as well as the mobility of the factors (coded FMOBFE in the model). Full factor employment is achieved by fixing the quantity supplied of each factor to the observed factor endowment level. An economy-wide factor wage variable, endogenously determined by the CGE model, assures that the sum of demands from all activities equals the quantities supplied (Lofgren *et al.,* 2002). The fact that each activity pays an activity-specific wage, which is the product of an economy-wide wage and an activity-specific wage distortion term (WFDIST), ensures the mobility of factors between activities. For the second closure (FACTFE), which also assumes full factor employment, the factor market is segmented, i.e. the factors are activity specific. In the third alternative (FMOBUE), it is possible to assume that a factor is unemployed and that the real wage (economy wide wage variable) is fixed, whereas the factor supply is endogenised and therefore flexible.

The three alternative factor market closures considered above are factor and simulation specific. This implies that a group of factors (i.e. land, capital or labour), or any sub-group thereof (i.e. unskilled labour) or an individual factor (i.e. Northern Cape Coloured and Asian High-Skilled and Skilled labour) can be specified with a particular closure for a specific simulation. When analysing the effect of external shocks (simulations) on the economy, sensitivity analysis with different factor market closures can be analysed to highlight the potential impact thereof.

4.4.4.5 Choice of closure combinations

For each of the three macro balances explained above, a closure rule must be specified, as these balances involve new flow equilibrium conditions. Robinson and Lofgren (2005) explain that the appropriate choice between the different macro closures in the classic CGE model depends on the context (domain of applicability) of the analysis. For a single-period (static) model such as this CGE model adopted for the NCP, Lofgren *et al.* (2002) suggest a "Johansen closure" combination of fixed foreign savings, fixed real investment, and fixed real government consumption for analysing the equilibrium welfare changes of alternative policies. In terms of the closures described above, the combination can be represented by the codes ROWCLOS1, SICLOS4 or SICLOS5 and any one of the three government closures. The advantage of such a closure is that it avoids the misleading welfare effects that appear when foreign savings and real investment change in simulations with a single-period model.

The savings-driven "neoclassical closure" is another macro closure often used in applied work in which investment is determined by the sum of private, government and foreign savings. In terms of the pre-programmed closure rules, the neoclassical closure differs from the Johansen closure in that it uses SICLOS3 instead of SICLOS4 or SICLOS5.

A third closure combination may be desirable when the analysis aims to capture the likely effect of an exogenous shock or policy change in a given setting. Lofgren *et al.* (2002) explain, for example, that in order to explore the role of complementary policies, it may be preferable to impose a closure that more closely mimics the real world with simultaneous adjustments in the three components of absorption. In such case, SICLOS1 or SICLOS2 are useful options.

The macro-economic closure rules selected for the purpose of the simulations in the NCP model include:

- Savings-investment – Investment driven savings – uniform marginal propensity to save (MPS) rate for selected institutions (**SICLOS1**)
- Government – Flexible government savings with fixed direct tax (**GOVCLOS1**)
- External or Rest of World – flexible exchange rate with fixed savings (**ROWCLOS1**)

4.4.4 Model code

The CGE model described above is written and solved in the computer modelling language called GAMS (General Algebraic Modelling System). The CGE model for the NCP is solved as a Mixed Complementary Programming (MCP) problem with the PATH solver algorithm. For the interested reader, the GAMS code of the equations used in the CGE model and the simulation code are provided as Appendix 4C and 4D respectively at the end of this document.

The SAM database, variable (set) descriptions, elasticities and population figures are captured in a MS Excel file, which is used as an include file into the GAMS code of the CGE model via a GAMS Data Exchange (GDX) file. The solution file of the calibrated CGE model, in turn, is read into the simulation GAMS file, after which the selected simulated result parameters are re-exported to MS Excel via a GDX file. These simulated parameters are then further manipulated in MS Excel into usable and understandable tables and figures as shown in Chapter 5.

4.5 LINKAGES BETWEEN MACRO AND MICRO MODELS

Feedback effects between micro- and macro-model levels can be broken down broadly into direct and indirect effects. Direct effects correspond to partial equilibrium effects, which can be explained as the effect of a *ceteris paribus* change in farm output prices on crop supply, for example. Indirect effects, in contrast, are due to general equilibrium effects. As explained by Diao *et al.* (2004) the overall effect of a policy change or any other economic shock is the sum of the direct and indirect effects.

Diao *et al.* (2004) further explain that the type of analysis that can be done by such a micro-macro linkage framework is important for two main reasons in the case of irrigation agriculture: Firstly, such an analysis shows that the importance (intensity of use) of water and also other resources in production is essential in understanding how a change in macro-economic policy can cause the shadow price of water to rise or fall, and more important also who in society benefits and who loses from reforms or other shocks. Secondly, the same forces are also essential in understanding how the reallocation of water to equate its marginal value product among alternative crops (uses) affects the rental rates of other resources, such as labour, capital and other economy-wide resources.

4.5.1 Micro-macro linkages (Bottom up)

The basic decision-making unit in a water economy is an irrigated farmland operator. Over the short run, farmers take as a given the production technology available, as well as the input prices and output prices, and decide on the input (including water) allocation and consequently on output supply (Diao *et al.*, 2004). Diao *et al.* (2004) explain that a micro unit can also consists of a group of farmers in a confined geographical location, operating under the same agro-climatic and economic conditions and extracting irrigation water from the same source.

Diao *et al.* (2004) explain that in principal, a micro model can be approached in two ways: Full linkage, i.e. embedding the farm model into the CGE model, or top-down (stand-alone) linkage. In the case of a full linkage, the representative farms are treated as a small part of the economy in the macro model. Due to the nature and scope of the farm model in the case of irrigation agriculture in the Northern Cape, as well as the data limitations of the macro model, embedding the farm models into the macro model does not appear to be the most workable option.

In a bottom-up linkage, shocks are introduced of a farm (micro) level, resulting in changes in outputs and therefore different structures. The changes in outputs are then used together with economic multipliers calculated from the SAM to determine the backward economic linkages of specific sectors.

Figure 4.3 provides a schematic overview of possible micro-macro linkages. Typical links between the micro model and the macro model include, amongst others, water allocation reforms, such as changing the water assignment rules, changing water-pricing methods, or the introduction of institutions and mechanisms for water trading and water rights. Such reforms affect farmers' use of water (as well as other production inputs) and therefore also agricultural production. When applied in a number of regions and given a significant size/contribution of the irrigation agricultural sector, these changes will affect input and output prices at the national level. The changing prices will then feed back, affecting the micro units (Diao *et al.,* 2004).

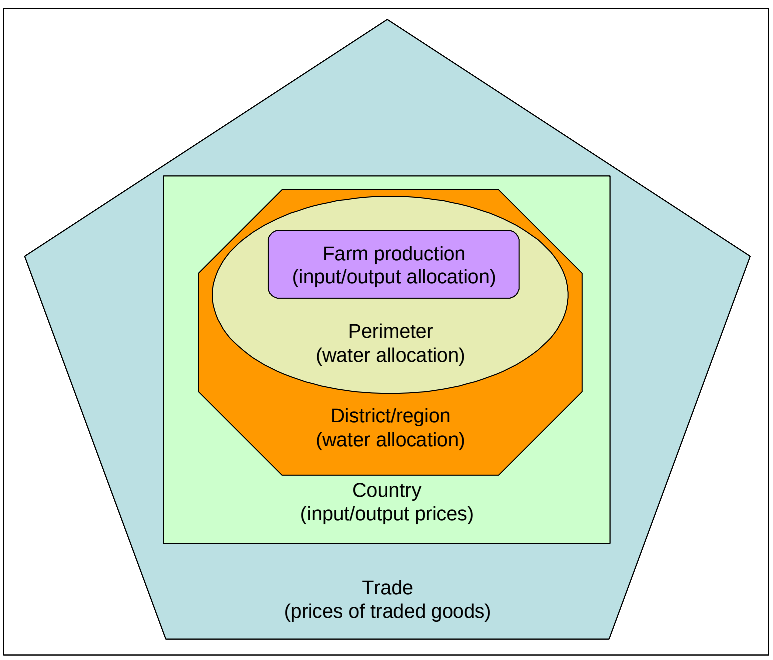


Figure 4.3: Micro-macro links
Source: Adopted from Diao et al. (2004)

In the case of a top-down linkage framework, prices are treated as exogenous to the farm model and therefore as being determined by the proposed macro framework. When one wants to investigate a shock, the CGE model is shocked, leading to changes in the equilibrium prices. Through this linkage, the farmer in the farm model, facing different prices, will adjust his/her production decision in order to maximise profits. These effects, as shown by Diao *et al.* (2004), can then be separated into direct, indirect and total effects.

4.5.2 Macro-micro linkages (Top down)

The regional economy consists of many sectors that interact at the marketplace to determine the prices of goods and services (including agricultural inputs and outputs). In addition to this, Diao *et al.* (2004) explain that these prices of trade inputs and outputs are set at the country/world markets and therefore affect the regional prices. Irrigators compete for resources (water, capital and labour) with other sectors, and the overall supply of agricultural products affects their output prices (Diao *et al., 2004).*

Diao *et al.* (2004) list three possible links between the macro-economic model and the micro-level model, namely:

- The prices of purchased inputs and outputs, which are determined at the macro level and taken as given by farmers – the typical price-taker situation. These prices are sensitive to government policies (taxes and subsidies) and affect the derived demand for irrigation water.
- Trade policies (tariffs and other trade barriers) affect the prices of traded agricultural inputs (fertiliser, pesticides, seed, fuel) and outputs.
- National and regional water projects and policies (e.g. new infrastructure, reallocation of water), which affect water supply constraints and the cost of water supply.

4.6 CONCLUSION

Devarajan and Robinson (2002) state that during the last four decades since Johansen's Norway model, applied or computable general equilibrium models (AGE or CGE respectively) have grown in importance as both research and policy analysis tools. Although their use was initially limited to universities and research institutions, Devarajan and Robinson (2002) further explain that CGE models are nowadays more frequently used by government in policy formulation and debate. The range of issues on which CGE models have had an influence is quite wide, including structural adjustment policies, international trade, public finance, agriculture, income distribution and energy and environmental policy (Devarajan and Robinson, 2002).

According to Devarajan and Robinson (2002), there exist a trade-off between using a structural model, which requires a large number of structural parameters to be estimated, and a reduced-form model with far fewer parameters. Devarajan and Robinson (2002) further point out that many reduced-form models are so limited in their domains of applicability as to be virtually useless in policy analysis. They further suggest that it is better to have a good structural model capturing the relevant behaviour of economic actors and their links across markets, even if the parameters required are imperfectly estimated, because of the domain of applicability of such models makes them far more useful for policy analysis.

In terms of the validation of the NCP CGE model, simulations similar to those analysed in PROVIDE (2005a) and PROVIDE (2005c) at national level were run with the NCP CGE model. Key outputs were compared between the different CGE models in order to validate the NCP CGE model which provides very similar results.

From the discussions above, it is clear, in the first instance that significant advantages arise from using the SAM – CGE modelling framework instead of an I/O framework. Second, it is also clear from the reviewed literature that structural models, such as a CGE, are preferred over and above other reduced-form models. The simulated results generated by the CGE model developed for the NCP are reported and discussed in the next chapter.

CHAPTER 5

SIMULATING THE EFFECT OF MARKET CHANGES – A CGE ANALYSIS

Table of Contents:

5.1 INTRODUCTION 115
5.2 SIMULATING A DECREASE IN WORLD EXPORT PRICE OF FRUIT (PWEDECR) BY MEANS OF THE CGE MODEL 116
5.2.1 Sectoral impacts (effect on activities) 118
5.2.1.1 Intermediate input costs 121
5.2.1.2 Activity price and quantity effects 122
5.2.1.3 Activity income effects 124
5.2.2 Commodity effects 125
5.2.3 Factor Impacts 127
5.2.3.1 Employment 128
5.2.3.2 Factor rental/wage rates 130
5.2.3.3 Return to land 131
5.2.4 Socio (household) and welfare impacts 132
5.2.5 Government effects 135
5.3 CONCLUSION 135

List of Figures:

FIGURE 5.1: NORTHERN CAPE PROVINCIAL MAP 117
FIGURE 5.2: CHANGE IN REGIONAL AGRICULTURAL GDP AT FACTOR COSTS (GDPTAB2P) .. 119
FIGURE 5.3: PRICE CHANGES OF ACTIVITY OUTPUT (PAXP) 120
FIGURE 5.4: AGGREGATE ACTIVITY INTERMEDIATE INPUT PRICE (PINTAXP) 122
FIGURE 5.5: ACTIVITY PRODUCER PRICE (PATAB) 123
FIGURE 5.6: DOMESTIC AGRICULTURAL ACTIVITY LEVELS (QAXP) 124
FIGURE 5.7: PRICE CHANGES OF ARABLE CROPS AT DIFFERENT LEVELS (IMPORT PRICE - PMXP, COMPOSITE COMMODITY PRICE - PQXP, DOMESTIC SUPPLY PRICE - PDSXP) 126
FIGURE 5.8: QUANTITY EFFECTS OF ARABLE CROPS (DOMESTIC SALES - QDXP, COMPOSITE MARKETED QUANTITY - QQXP, IMPORT - QMXP, EXPORT - QEXP) 127
FIGURE 5.9: EMPLOYMENT OF SEMI- AND UNSKILLED LABOUR CATEGORIES (QFSXP) 129
FIGURE 5.10: EMPLOYMENT DEMAND PER LABOUR (WITH FULL EMPLOYMENT ASSUMED) CATEGORY FROM NORTHERN CAPE AGRICULTURAL ACTIVITIES (QFXP) 129
FIGURE 5.11: EMPLOYMENT DEMAND PER LABOUR CATEGORY (QFXP) 130

FIGURE 5.12: RETURNS TO NORTHERN CAPE LAND UNDER FULL AND UNEMPLOYMENT SCENARIO (WFDISTXP) 132
FIGURE 5.13: HOUSEHOLD POPULATION DISTRIBUTION IN THE NCP 133
FIGURE 5.14: HOUSEHOLD CONSUMPTION EXPENDITURE (EHXP) FOR FULL EMPLOYMENT AND UNEMPLOYMENT SCENARIOS........ 134
FIGURE 5.15: EQUIVALENT VARIATION (EV) FOR THE NCP HHS........ 134

List of Tables:

TABLE 5.1: NCP AGRICULTURAL REGIONS........ 117
TABLE 5.2: QUANTITY OF FRUIT OUTPUT (QXACXP), SHARES OF TOTAL OUTPUT AND SIMULATED RESULTS FOR THE NCP AGRICULTURAL ACTIVITIES........ 121
TABLE 5.3: ACTIVITY VALUE ADDED EFFECTS (R VALUES FOR 2000)........ 125
TABLE 5.4: SEMISKILLED AND UNSKILLED LABOUR CATEGORIES IN THE MODEL 128
TABLE 5.5: DESCRIPTION OF THE NCP HOUSEHOLD CATEGORIES........ 133
TABLE 5.6: GOVERNMENT FINANCE 135

CHAPTER 5

SIMULATING THE EFFECT OF MARKET CHANGES – A CGE ANALYSIS

"Models are to be used, not believed" Henri Theil

5.1 INTRODUCTION

As explained in Chapter 4, the base solution of the CGE model is calibrated to the adjusted database (SAM) and therefore duplicates it as a "base solution". A critical and central assumption that is made in this study is that all arable crops grown in the NCP are irrigated, i.e. due to the relatively low rainfall; rain-fed arable crop production is virtually impossible and therefore negligibly small in the NCP. It is however important to remember that the SAM used in this analysis is a National SAM for South Africa, with disaggregated detail for agricultural activities within the NCP, whereas the agricultural activities for the remaining eight provinces are each aggregated into a provincial total. Having said that, cognisance should be taken of the fact that if a tariff or price (exogenous world price) of a commodity is "shocked", it reflects a national change, i.e. the tariff or price of the commodity is then changed on a nationwide basis. In order to quantify the impact of the shocks on the economy of the NCP, selected NCP variables are then analysed. All figures and simulation results reported in this chapter are for the base year 2000, as in the case of the PROVIDE SAM base year.

The shock reported on in this chapter was simulated to quantify its potential impact relative to the base solution, specifically due to the export-orientated nature of irrigated fruit crops in the NCP. This simulation (abbreviated as PWEDECR) represents a 20% decrease in the export price (world price) of locally produced fruits and therefore specifically also influences the NCP economy.

Alternate factor market closures (full employment vs. unemployment) for unskilled labour categories was analysed in addition to highlighting the potential impact. In terms of the unemployment scenario, the model specification is altered to allow for the unemployment of the unskilled labour factors. This is done by fixing the labour supply, which therefore becomes the market-clearing variable. This is in contrast to the full-employed labour factors where the activity linked wage rates are used to clear the labour market. The unemployment scenarios are distinguished by a **UE** suffix (i.e. PWEDECRUE). These effects, where significant, are reported and discussed in terms of the macro economic variables under discussion. Macro economic closure rules, as discussed in Chapter 4, may in some instances have a significant impact on the simulated results. It is therefore important when interpreting the simulated results that the mechanism by which equilibrium in the economy is achieved in a CGE model is kept in mind (refer to section 4.2.4).

The simulation (PWEDECR) introduced above is focused on the arable crops i.e. all agricultural commodities excluding livestock. For modelling purposes, a commodity sub-set was created for arable crop commodities in the CGE model (labelled CIARG in the GAMS model code), which includes the following seven agricultural commodity groups (code in brackets): summer cereals (C1a), winter cereals (C1b), other field crops (C1cde), potatoes and vegetables (C1f), wine grapes (C1g), fruit (C1ijk), and other horticulture crops (C1k). As explained above as well as in Chapter 4, the critical assumption made regarding the insignificance of rain-fed arable commodity production in the NCP, applies specifically to these simulations. Therefore, it is assumed that if a shock is applied to the economy, the resultant effect on arable agricultural production can be directly linked to irrigation agriculture in the NCP. It is however important to note that this assumption only applies to the NCP, given that the simulations are national, as the rain-fed component of total arable agriculture in the remaining part of South Africa is quite significant. The effect on an arable commodity in any other province can therefore not be traced back to irrigated agriculture without any further segregation between irrigated and rain-fed production.

In Chapter 3, it was shown that the seven arable crops (as listed in the paragraph above) as a group contribute nearly 60% in value terms to the total primary agricultural production (arable crops and livestock) in the NCP (PROVIDE, 2005b), of which fruit contributes 41% of the total arable crop production in the NCP in value terms. Chapter 3 also provides a short overview of the fruit industry in the NCP (see section 3.5.1.1). According to OABS (2006), table grapes and dry grapes (raisins) together comprise approximately 95% of the total value of fruit production in the NCP.

5.2 SIMULATING A DECREASE IN WORLD EXPORT PRICE OF FRUIT (PWEDECR) BY MEANS OF THE CGE MODEL

Linked to the overall objective, to quantify the effect of external shocks in irrigation agriculture on the macro-economy of the Northern Cape, this simulation was specifically chosen. It further also closely mimics the reality that was experienced during the last few years in the world fruit market. This was mainly caused firstly by the strengthening of the rand and secondly increased competition from South American countries, like Brazil and Chile, causing an increase in fruit supply in Europe, specifically during the “early advantage time span” the NC table grape producers enjoyed in the southern hemisphere table grape production season. It can therefore be seen as a long term effect, unlikely to return to the original situation. As mentioned above, PWEDECR represents a 20% decline in the South African export price of fruit on the world market.

Table 5.1: NCP agricultural regions

Region	Major towns in statistical region
NC1	Gordonia, Namakwaland (Including Upington, Springbok) and Kenhardt
NC2	Calvinia, Sutherland and Williston
NC3	Fraserburg, Victoria West
NC4	Hopetown, Britstown, De Aar, Philipstown, Richmond, Hanover, Colesberg and Noupoort
NC5	Kuruman, Postmasburg and Hay
NC6	Prieska and Carnarvon
NC7	Herbert, Barkly West, Warrenton and Hartswater
NC8	Kimberley

Source: PROVIDE (2006)

The results of the world fruit price simulation (PWEDECR) are subdivided into six sub-sections. Firstly, section 5.1.1 provides an overview of the local fruit industry, which is further separated into the national and more specifically, the NCP fruit industry. In the remaining five sections the actual simulation results are reported in the following order: activities (sectors), commodities, factors of production, household (social) as well as the effect on the government.

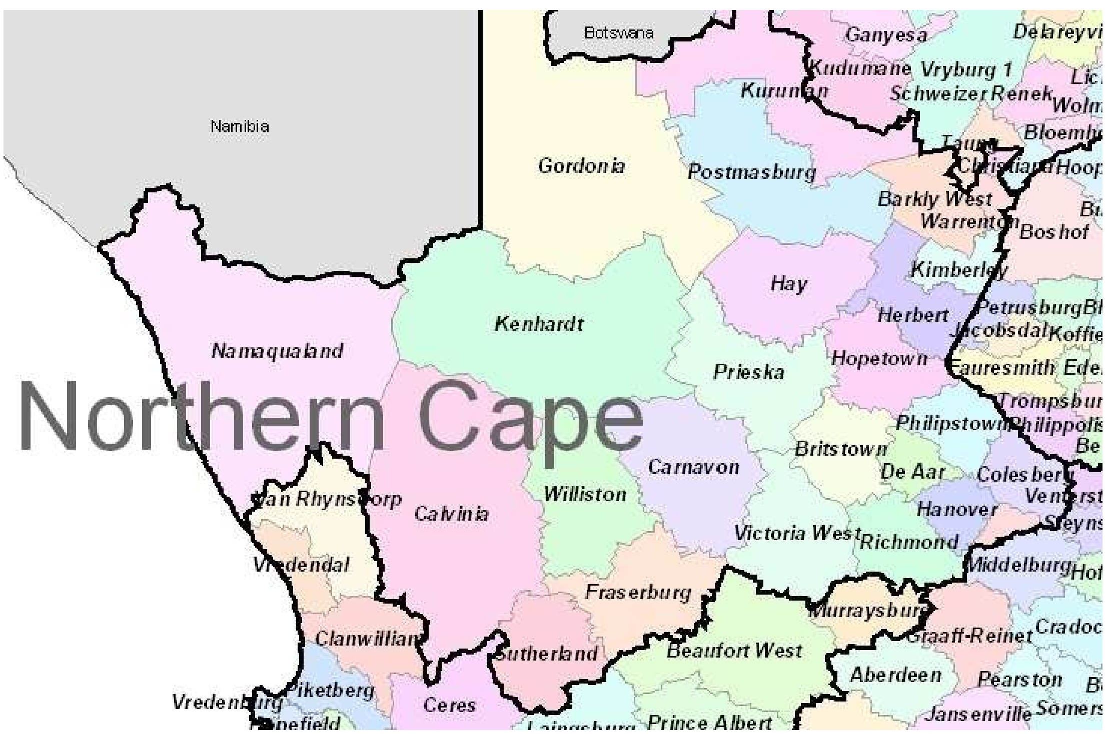


Figure 5.1: Northern Cape Provincial Map
Source: Northern Cape DWAF (2007)

For the purposes of the SAM database, the agricultural activities in the NCP were disaggregated into eight regions (coded NC1 to NC8 for modelling purposes) according to the towns as listed in Table 5.1 (PROVIDE, 2006). For the convenience of the reader, the major towns in each region are again listed in Table 5.1 and are visually represented in Figure 5.1.

5.2.1 Sectoral impacts (effect on activities)

According to the simulation results from the CGE model on an aggregate level, a 20% decrease in the world price of fruits reduces the national GDP by 0.027%. In total, the agricultural GDP for the NC activities decreases by 1.8% in total. Figure 5.3 shows the change, as a result of the simulated world fruit price decrease, in the real Gross Domestic Product (GDP) at factor cost for the eight Northern Cape (NC) agricultural activity regions for both the full employment and unemployment labour scenarios. NC1 (Gordonia, Namakwaland and Kenhardt), which represents the lower Orange River in terms of irrigation agriculture, is by far the largest fruit-producing region (93% of the total provincial fruit production) in the NCP, followed by NC7 (3.5%) and NC8 (2.8%) (see also Table 5.2, column 3). The effect on regional GDP of NC1 and NC8, that is the most predominant fruit producing regions (see Chapter 3), is found to be in contrast with the simulated effects on the other six regions in the in the NCP. Being the largest fruit-producing region in the NCP, it therefore seems logical that the PWEDECR simulation will affect NC1 the most, with a decline in regional GDP of 15.7% followed by Kimberley (NC8) with a negative impact of 0.7%. The effects on the remaining six regions are positive throughout, with an average increase of 7.7%. A possible explanation is the low level of fruit produced in these regions, and therefore as a result of the lower world fruit price, more fruit might flow to these regions from the fruit producing areas.

Furthermore, in terms of the labour employment scenarios, it is clear from Figure 5.2 that in the case of a decrease in regional GDP, the unemployment scenario dominates the full employment assumption, whereas the opposite is true when the regional GDP increases. This can be ascribed to the labour intensive nature of the fruit industry that forms a significant share of total agricultural output in these specific activities.

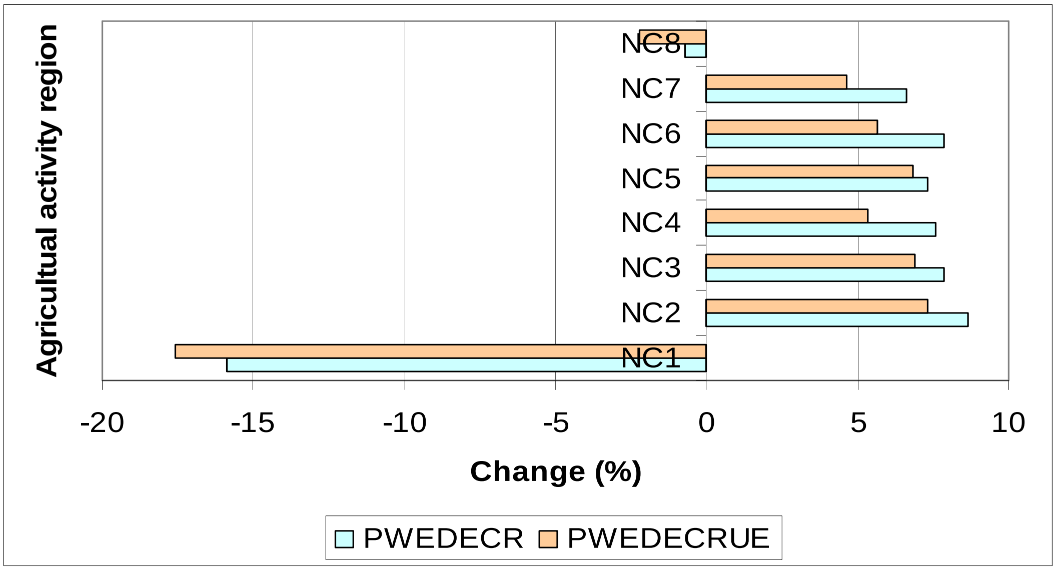


Figure 5.2: Change in regional agricultural GDP at factor costs (GDPTAB2P)

The average activity output prices are shown in Figure 5.3. In contrast to the changes in regional GDP, the price changes of the unemployment scenario are smaller than the full employment scenario in the case of a price decrease and likewise greater for price increases. The direction of the activity price changes under the full employment scenario for regions NC2, NC4, NC6 and NC7, despite being relatively small (i.e. less than 0.2%), is the opposite when compared to the unemployment labour scenario. This proves that if factors of production in an economy are immobile, i.e. not able to adjust to the quantity demanded, other distortions like price effects are likely to result. Furthermore, it is important to consider the price changes of the individual commodities in the production mix of the different activities (regions) as well as the relative importance of the subsequent commodity within that specific region.

Table 5.2 illustrates the fruit production output and therefore the concentration in fruit production among the agricultural activities (regions) in the NCP as well as the importance of fruit as a commodity within each region and the simulated results for the full and unemployment scenarios under the world fruit price simulation. The concentration of fruit production in the NCP is detectable from the third column of Table 5.2. The fourth column provides an indication of the relative importance of fruit output in terms of each activity's (region) total agricultural output. In the NCP for example, nearly 64% of the total agricultural output (in quantity terms) in NC1 comes from fruit, whereas 13.6% and a mere 3.7% are made up by fruit in NC8 and NC7 respectively.

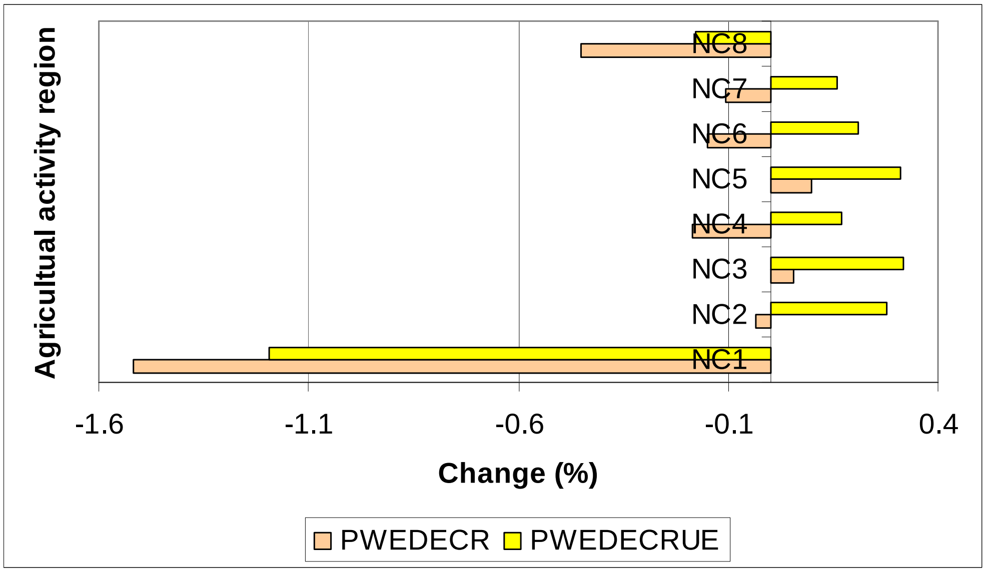


Figure 5.3: Price changes of activity output (PAXP)

This high level of concentration of fruit production in one region (NC1) of the NCP as well as the relative dominance of fruit in terms of the specific total agricultural output within NC1 can be seen as the reason for the relatively large (15.9% and 17.6% for the employment scenarios respectively) simulated impact. Kimberly (NC8), which has the third highest share of fruit output, experienced a -0.7% and -2.2% decrease in fruit output, for the full- and unemployment scenarios respectively, as a result of the change in the world fruit price simulation. The fruit output of the remaining six regions, all with a regional fruit output share of less than 4%, is expected to increase their fruit outputs with between 6.6% and 8.6% in the case of the full employment scenario, which can be seen as the result of inter regional trade. Except for NC7, which produces 3.5% of the total fruit within the NCP, the simulated changes of all other NC regions can be disregarded as the changes are from a small or relatively insignificant base.

Similar to the notion of activity price changes described above, the decreases in the quantity of fruit output is larger for the unemployment scenario, whereas a larger impact is recorded by the full employment scenario in the situations where an increase in fruit output is observed. It again shows that when distortions in an economy are present, (i.e. unemployment is not allowed) changes in affected sectors are different. This can typically be seen as a situation where farmers are unable to lay off some of their workforce, and because of this, they try to minimize their losses by producing more compared to when unemployment is allowed in the model specification.

Table 5.2: Quantity of fruit output (QXACXP), shares of total output and simulated results for the NCP agricultural activities

Region	Million units	Fruit as share of total NC fruit output (%)	Fruit as share of total activity output (%)	PWEDECR (% change)	PWEDECRUE (% change)
NC1	946.5	92.9	63.9	-15.9	-17.6
NC2	0.1	0.0	0.0	8.6	7.3
NC4	0.5	0.0	0.1	7.6	5.3
NC5	4.8	0.5	1.1	7.3	6.9
NC6	2.5	0.2	1.0	7.9	5.6
NC7	35.9	3.5	3.7	6.6	4.6
NC8	28.7	2.8	13.6	-0.7	-2.2
NCP total	**1018.9**	**100**			

5.2.1.1 Intermediate input costs

The price changes of selected activities' aggregate bundles of intermediate input costs are shown in Figure 5.4 for the full employment scenario. The difference between the labour employment (full vs. unemployment) scenarios are all less than 0.01% and are therefore not reported in detail for both scenarios. The intermediate input cost of the two activities that predominantly use fruit in their production process, i.e. beverages and tobacco as well as fruit production activities, increases by 2.8% and 1.4% respectively as a result of the decreasing world fruit price. The price increases for the other activities are relatively small, less than 0.6%, and are not reported here. However, the intermediate input prices for the majority of the activities accounted for in the model experience a decline, ranging between -0.27% and -0.03%. The intermediate input price is calculated in the model as the weighted average between the domestic commodity price and the quantities of the corresponding commodities demanded for intermediate input use. Due to vast differences between the commodity output mixes produced by the individual activities, further detailed interpretation of the intermediate input prices is not provided.

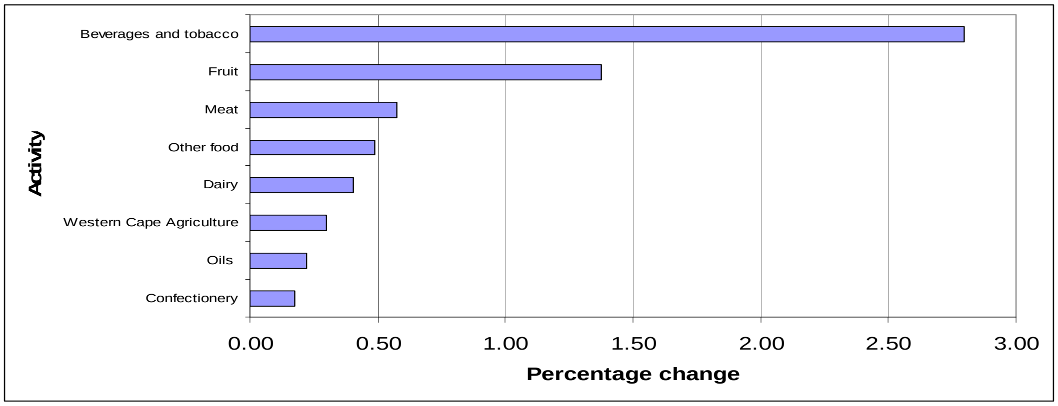


Figure 5.4: Aggregate activity intermediate input price (PINTAXP)

5.2.1.2 Activity price and quantity effects

Figure 5.5 show the effects on the producer prices that selected agricultural activities receive for production under both the full and unemployment scenarios. These producer prices (labelled PATAB in the GAMS code) are calculated, in a similar manner to the intermediate input price described above, as the weighted average price the activity (production region) achieves, given the corresponding share of the specific commodity production levels. The relative importance (share) of a specific commodity output in terms of the total regional commodity output is therefore a key determinant in this "weighted average" activity producer price. Given that the simulation under investigation only focuses on the world fruit price, the regional fruit shares of total production for the NCP activities (as reported in column 4 of Table 5.2 above) should be kept in mind along with the interpretation of Figure 5.5. The agricultural activities omitted from the graph did not indicate any significant simulated effects.

The following NCP agricultural activities (grouped by region) - NC1, NC4, NC6, NC7 and NC8 - all experienced a decline in their respective output prices, ranging from a low of -0.1% for both NC6 and NC7 to a maximum decline of -1.5% for NC1. The reported declines for the NCP activities clearly indicate the positive correlation between the activity producer price decline and the share of fruit production within each region. For example, the largest decline in activity producer prices (-1.5%) for NC1 corresponds to the fact that fruit is the most dominant commodity (64% of the total activity output) produced within NC1. Similarly, NC8, which has the second highest fruit output share (13.6%), recorded the second largest decline (0.4%) in activity producer prices with the NCP.

The direction of change for both employment scenarios are alike for all the activities reported except for NC4, NC6 and NC7. As observed earlier, the full employment scenarios are more dominant (are greater) than negative changes in activity price decreases, whereas the positive changes in the producer prices for the unemployment scenarios tend to be greater (except for the North West (NW) Province).

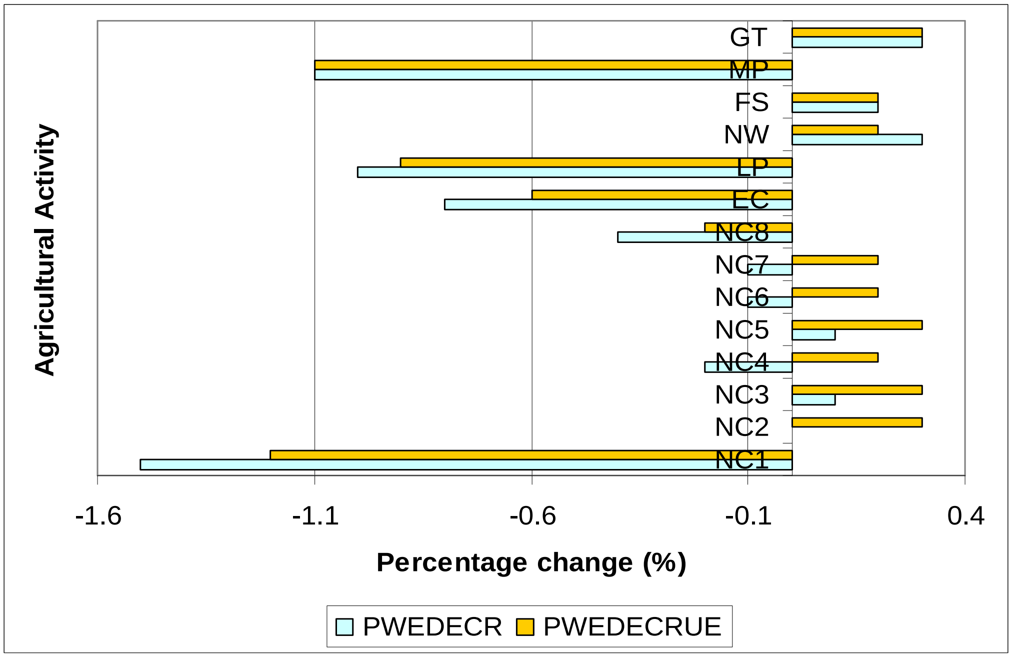


Figure 5.5: Activity producer price (PATAB)

Figure 5.6 illustrates the simulated effects on domestic agricultural (primary) activity production levels, again for both labour employment scenarios. Similar to the direction of change in the producer prices reported above, the agricultural activity output of NC1 (Namaqualand) and NC8 (Kimberley) are contracting following the 20% decrease in the world fruit price. In addition to these two NCP regions, agricultural activities in other provinces, which are also typically known for fruit production i.e. the Western Cape (WC), Eastern Cape (EC), Limpopo (LP) as well as Mpumalanga (MP) also show a decrease of 0.7%, 7.3%, 10.5% and 12.6% respectively in their activity output levels. Again, it should be kept in mind when interpreting these changes that the relative importance of fruit as a commodity within each production activity (province) plays a pivotal role in the magnitude of the simulated change.

In contrast to the activity prices, larger declines are mainly recorded in the scenario where unemployment is allowed for the unskilled labour categories, whereas the increases in activity output levels are mostly dominated by the full employment assumption.

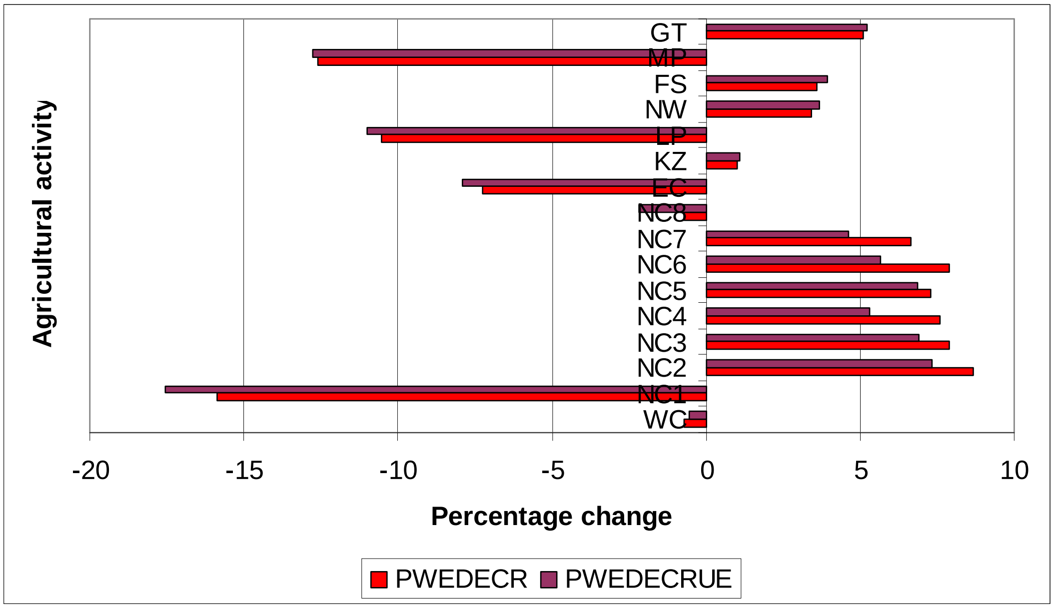


Figure 5.6: Domestic agricultural activity levels (QAXP)

5.2.1.3 Activity income effects

Table 5.3 reports on the change in the value added price and quantity effects of the PWEDECR simulation for the provincial agricultural activities, including the disaggregated regions in the NCP, as well as the fruit, beverage and tobacco activities. These value added figures can be used as a proxy for expansion or contraction of a sector within a specific region. The second column in Table 5.3 provides the total base/equilibrium value added for selected activities, i.e. that the CGE model provides at initial equilibrium of the economy. Column 3 and 4 provide respectively the percentage change in the quantity of value added as well as the value added price resulting from the fruit price simulation/shock. The value change in the fifth column is simply the aggregated effect of the respective price and quantity changes in value added, which is then multiplied with the base value added to return the change in value added as reported in the last column of Table 5.3.

In the NCP, NC1 and NC8 again show contrasting results compared to the other six NCP agricultural activity regions. The largest negative effects experienced among the eight NCP activities are NC1 with an estimated R199 million decline in total value added, followed by NC8 with nearly R2 million. The value added in other provinces like WC, EC, LP and MP, also decrease between R67 million for the WC and R 488 million for MP. The relatively large effect in total value added experienced by NC1, LP and MP all result from the relatively large change (>10%) in the quantity of value added within the specific activity.

Table 5.3: Activity value added effects (R values for 2000)

Agricultural Sector (Activity)	Base value added (R millions)	Quantity of aggregate value added (QVAXP)	Price of value added (PVAXP)	Value change	Value change (R million)
		Percentage change (%)			
WC	R 7,223.8	-0.72	-0.20	-0.92	-R 66.7
NC1	R 1,111.4	-15.86	-2.04	-17.90	-R 198.9
NC2	R 172.7	8.65	-0.01	8.64	R 14.9
NC3	R 67.6	7.87	0.14	8.01	R 5.4
NC4	R 388.1	7.57	-0.24	7.33	R 28.4
NC5	R 257.8	7.31	0.21	7.52	R 19.4
NC6	R 188.7	7.88	-0.18	7.70	R 14.5
NC7	R 617.0	6.64	-0.16	6.48	R 40.0
NC8	R 144.4	-0.72	-0.62	-1.34	-R 1.9
EC	R 2,417.1	-7.28	-1.15	-8.43	-R 203.7
KZ	R 3,900.3	1.01	0.02	1.03	R 40.3
LP	R 3,322.0	-10.52	-1.66	-12.17	-R 404.4
NW	R 2,898.7	3.42	0.55	3.97	R 115.1
FS	R 3,997.9	3.57	0.52	4.09	R 163.6
MP	R 3,335.4	-12.58	-2.06	-14.64	-R 488.5
GT	R 1,875.7	5.11	0.61	5.72	R 107.2
Fruit	R 1,134.8	-2.88	-0.15	-3.03	-R 34.4
Beverages and Tobacco	R 8,632.1	-2.53	-0.11	-2.64	-R 227.9

5.2.2 Commodity effects

The changes in domestic supply (production) prices, composite commodity prices and import prices for the five arable crops (commodities) resulting from PWEDECR simulation, are reported in Figure 5.7 for both the full employment and unemployment scenarios. The changes in domestic supply prices (of commodities produced and sold domestically) of potatoes and vegetables increase by 3%, other field crops (0.94%), summer cereals (0.29%) as well as other horticulture (0.15%) increase for both the employment scenarios, whereas the corresponding prices of fruit (-8.3%) and winter cereals (-1.9%) are negatively affected as a result of the 20% decrease in the world fruit price. Compared to the domestic supply prices, the composite commodity (which is the aggregate between domestic sales and aggregate imports) prices for both employment scenarios are similar in magnitude for all commodities listed, because it is the weighted average between the import and domestic price.

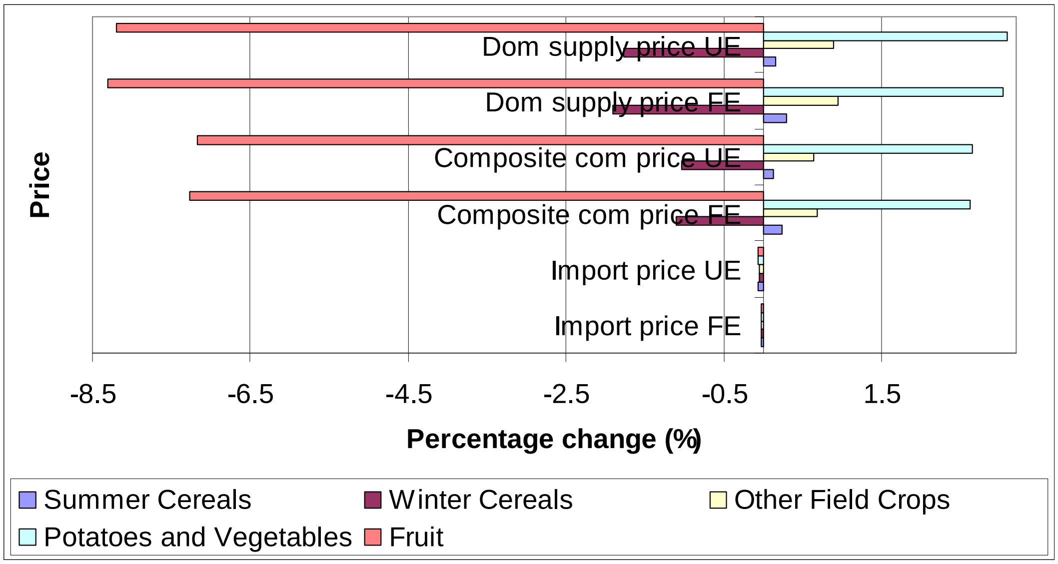


Figure 5.7: Price changes of arable crops at different levels (import price - PMXP, composite commodity price - PQXP, domestic supply price - PDSXP)

The price effects of wine grapes are omitted from Figure 5.7 for basically two reasons: Firstly, wine grapes are not traded internationally (due to their perishable nature and designated purpose) and therefore neither has a local import or export price. Secondly, due to its designated production purpose i.e. that it is only used as an intermediate input in the production of wine which is captured in the SAM in the beverages and tobacco activity and therefore loses its identity in this process.

The simulated results obtained from the model for the various price levels of wine grapes are relatively high and can be considered out of range with the composite commodity price resulting in a 55% increase and a 70% increase in the domestic supply price. Consultations with Punt (2006), revealed that similar difficulties were experienced with the wine grapes commodity as in some of the previous PROVIDE studies. A possible suggestion in this regard, which is not discussed further for the purposes of this study, is to aggregate the wine grapes and fruit commodities and re-run the CGE model and simulations to determine the impact on the results.

The simulated impacts on the quantities of arable crop commodities sold at four levels (domestic, composite, import and export) are shown in Figure 5.8 for both employment scenarios. As can be expected from the nature of the simulation (20% world fruit price decrease), the fruit quantities are the most affected among all arable crops.

As a result of the 20% decrease in the world fruit price, the quantity of fruit exports decreases by 37% on average for both employment scenarios. In addition to fruit exports, the export quantities of all other arable crops (except for winter cereals that increase by nearly 5%) decrease between approximately 1% for summer cereals and 11% for potatoes and vegetables. These are mainly driven by the slight decrease in the export price of the respective commodities

(0.014% on average), which in turn is probably propelled by the 0.022% decrease or appreciation in the exchange rate, making South African exported commodities more expensive for foreign markets.

On the import side, the simulation shows a 15% decrease in the quantity of fruit imports, again with an insignificant difference between the two employment scenarios. The decrease in fruit imports is probably compensated for by locally produced fruit that is not exported as a result of the lower world fruit price. The imports of summer cereals (0.2%), other field crops (0.6%) and potatoes and vegetables (5.5%) increase as a result of the simulation under investigation, whereas winter cereals (2.3%) and other horticultural (0.52%) imports also decline in a similar manner to the fruit imports.

Resulting from these changes in international trade quantities, the domestic fruit sales and therefore also the composite marketed fruit quantity, increase on average by 5.6%. Except for the domestic sale of winter cereals, which increases by 1%, the domestic sales as well as composite marketed quantities of all other arable crops decrease as a result of the world fruit price shock.

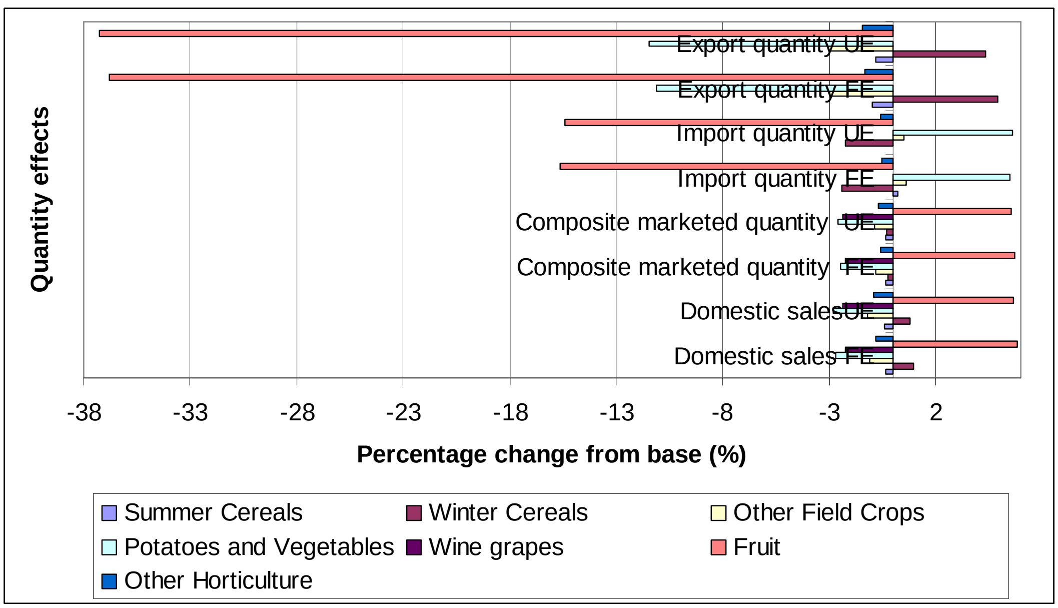


Figure 5.8: **Quantity effects of arable crops (domestic sales - QDXP, composite marketed quantity - QQXP, import - QMXP, export - QEXP)**

5.2.3 Factor Impacts

The simulated impacts on the three factors of production; labour, capital (GOS) and land, specified in the SAM, are reported in this section. In the first sub-section (5.2.4.1), the effect on labour employment is given, followed by the capital income and return to land in the second and third sub-sections respectively.

5.2.3.1 Employment

It was explained earlier in this report that the semiskilled and unskilled labour categories were allowed to be unemployed in order to analyse their sensitive effect on the results. As a result of the specification of the factor market closure for labour, the supply of these labour categories (see Table 5.4 for detailed list) in this scenario (labelled with suffix UE, i.e. PWEDEC**UE**) is free to change as a result of an external shock to the economy, given a fixed factor wage rate. In the case where full factor employment is assumed the contrary is true, with the wage rate being specified as a variable and a fixed factor supply. It is thus possible to determine the potential impact on employment of these unemployed allowed labour categories as a result of the 20% decrease in the world price of fruit.

Table 5.4: Semiskilled and unskilled labour categories in the model

Model abbreviation	Description	Model abbreviation	Description
FWCaf	Western Cape African	FKZc	Kwazulu-Natal Coloured
FWCcusk	Western Cape Coloured and Asian Semi- and unskilled	FKZas	Kwazulu-Natal Asian
FECafusk	Eastern Cape African Semi- and unskilled	FNWaf	North West African
FNC2	Northern Cape African Semi- and Unskilled	FNWca	North West Coloured and Asian
FNC4	Northern Cape Coloured and Asian Semi- and Unskilled	FGTausk	Gauteng African Semi- and Unskilled
FNC6	Northern Cape White Semi- and Unskilled	FGTc	Gauteng Coloured and Asian
FFSafusk	Free State African Semi- and unskilled	FMPaf	Mpumalanga African
FFSc	Free State Coloured and Asian	FMPc	Mpumalanga Coloured and Asian
KFZafusk	Kwazulu-Natal African Semi- and Unskilled	FLPafusk	Limpopo African Semi- unskilled
FECc	Eastern Cape Coloured and Asian	FLPc	Limpopo Coloured and Asian

Source: Provide (2005b)

The simulated changes for the unemployed labour categories are reported in Figure 5.9A for the NCP, WCP, FSP and ECP, whereas the unemployed labour categories of the remaining six provinces are given in Figure 5.9B. From Figure 5.9 it is clear that the majority of the semi- and unskilled labour categories experience a decline in employment levels as a result of the fruit price simulation with only four out of the 20 reported categories showing a positive effect.

In terms of the semi- and unskilled labour categories employed in the NCP, African labour increases by 0.4%, whereas Coloured and White labour decrease by 1.1% and 2.2% respectively. It is interesting to note that the only other three categories in other provinces, that also show an increase in employment levels, are represented by African labour categories across the board, i.e. in the North West (0.4%), Free State (0.9%) and Gauteng (0.01%) provinces. Overall for all provinces, the largest decline experienced is in semi- and unskilled white HHs residing in the NCP with -2.2%, whereas Free State African semi- and unskilled labour shows the largest increase of 0.94%. On average the simulated employment levels of all semi- and unskilled labour employment decreases by 0.4%.

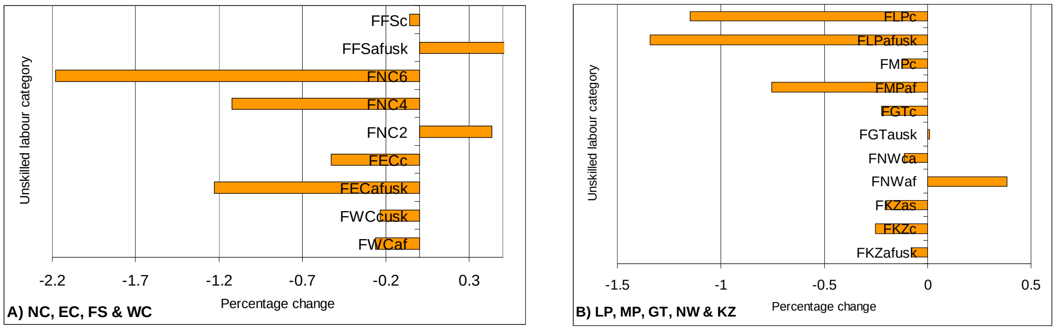


Figure 5.9: Employment of semi- and unskilled labour categories (QFSXP)

Figure 5.10 and Figure 5.11 reveal the change in the quantity of labour demanded per NCP category from the NCP agricultural activities (regions) respectively for full employment as well as for the scenario where unemployment of the semi- and unskilled labour categories is allowed. It is evident from both graphs that the quantity of labour demanded in NC1 and NC8 is negatively affected by the 20% decrease in the world fruit price. In the case of the full employment scenario (see Figure 5.10), the average quantity of labour demanded across all labour categories in NC1 declines with 17.7% compared to the 1.2% of NC8. In contrast to NC1 and NC8, on average, NC2 to NC7 shows a 7.9% increase in quantity of labour demanded across all labour categories. This increase in the labour demand can be linked back to the increase in activity output as described in Section 5.2.2 above.

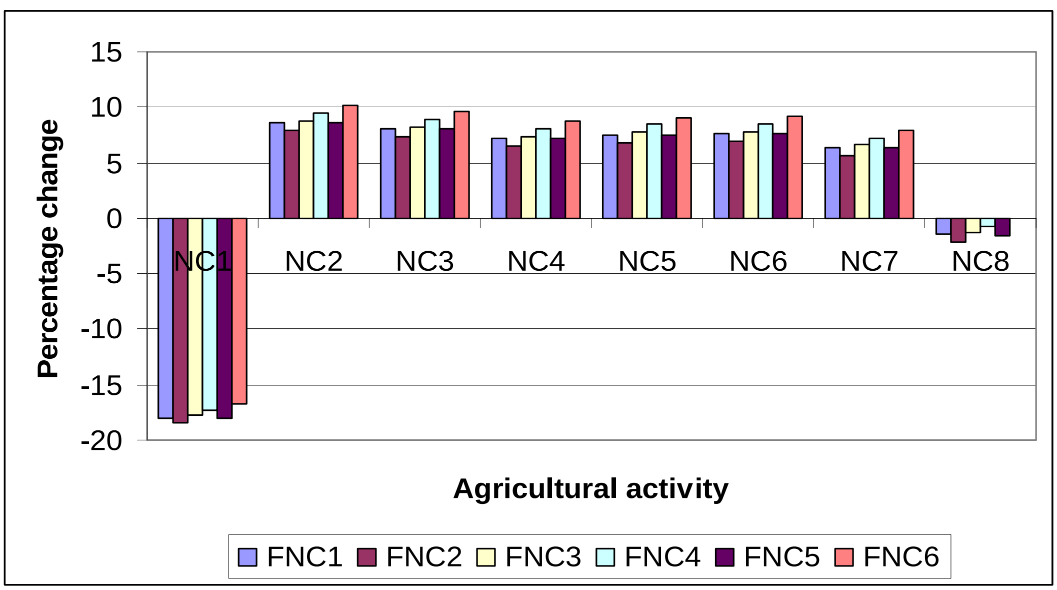


Figure 5.10: Employment demand per labour (with full employment assumed) category from Northern Cape agricultural activities (QFXP)

This can possibly be ascribed to the nature of the simulation, in the sense that NC2 to NC7 are not really fruit producing regions and therefore due to the reduction in the fruit price, the local demand for fruit in these regions increases.

In the case where unemployment of the semi- and unskilled labour categories is allowed, which might be more realistic in the South African situation, two interesting observations are worth mentioning (see Figure 5.11). Firstly, the average negative impacts observed for the labour categories NC1 and NC8 are larger for the unemployment (19.1%) scenario compared to the full employment (17.7%, see Figure 5.10) scenario. It is therefore clear that in reality the impact on labour, as a result of the world fruit price scenario, will be more severe, i.e. more jobs will be lost in NC1 and NC8 whereas fewer opportunities will be created in NC2 through NC7. Secondly, the variation in the change in quantity demanded across all six NCP labour categories is smaller (ten times on average) for the unemployment scenario compared to its full employment counterpart.

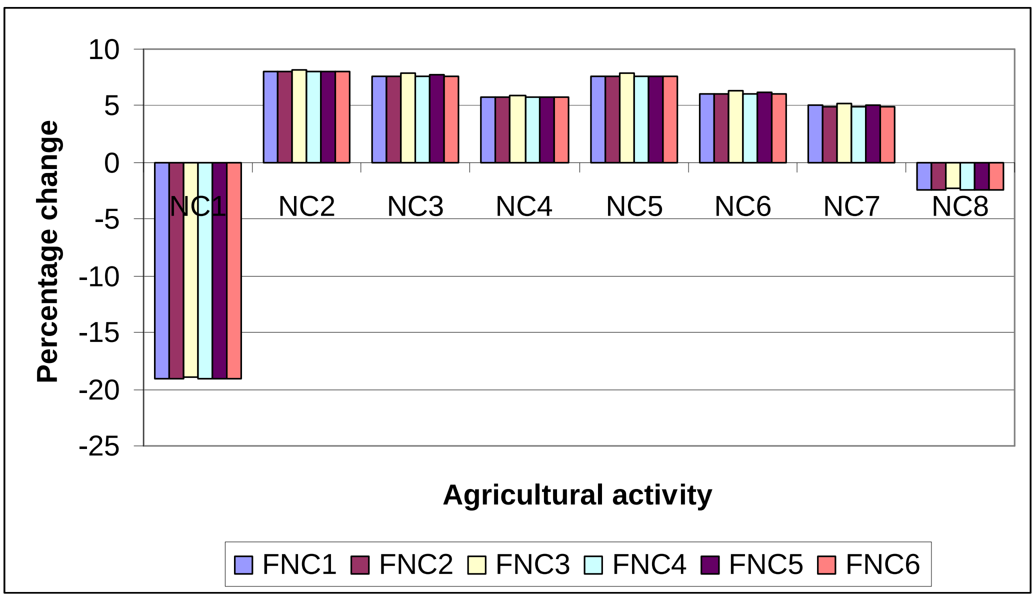


Figure 5.11: Employment demand per labour category (QFXP)

5.2.3.2 Factor rental/wage rates

As explained in the previous section, the factor market closure for unemployed factors of production assumes a constant wage rate for the corresponding categories. Therefore, income changes for these unemployed factors are a result of changes in employment levels. Given that the opposite is true for the factors with the full employment assumption, i.e. the skilled labour categories and GOS, a change in the factor wages facilitate the change in factor specific income. The change in the wage rate of the fully employed labour categories resulting from the 20% decrease in the world price of fruit, are virtually insignificant (-0.001%). A possible explanation for this relatively insignificant change in the labour wage rate may be that the share of the total labour force that directly depends on the fruit industry is relatively small.

The Gross Operating Surplus (GOS) or return to capital also decreases marginally (0.1%) as a result of the decrease in the world fruit price, which can be explained by following the same reasoning as in the case of labour.

Different from labour and capital, the land factor, which is also specified per province, is specified in the factor market closure of the model to be activity specific (i.e. immobile) as well as fully employed. Due to the fact that land cannot move from one activity to another (i.e. immobile), the quantity of land used stays constant (fully employed) as the economy adjusts to a new equilibrium within the CGE model.

5.2.3.3 Return to land

The rate of return to land as a primary production factor increases marginally by 0.2% on average for the country as a whole following the 20% decrease in the world price of fruit. More specifically, the return to land in the NCP increases on average by 2.7%. However, despite this positive impact, the major fruit producing regions in the NCP (NC1 and NC8) are negatively affected.

Figure 5.12 provides an indication of the returns to land in the eight NC regions under both the full employment and unemployment labour scenarios. What may be expected and analogous to some previous indicators discussed above is that the return to land in the major fruit producing regions (NC1 and NC8) is negatively affected by PWEDECR. The return to land in NC1 decreases by a significant 15.2%, whereas NC8 is down by 1.2%. In terms of the unemployment labour scenario, the negative return to land is inflated for these two regions, whereas the effect for the same scenario is smaller for the other six regions that experience a positive impact.

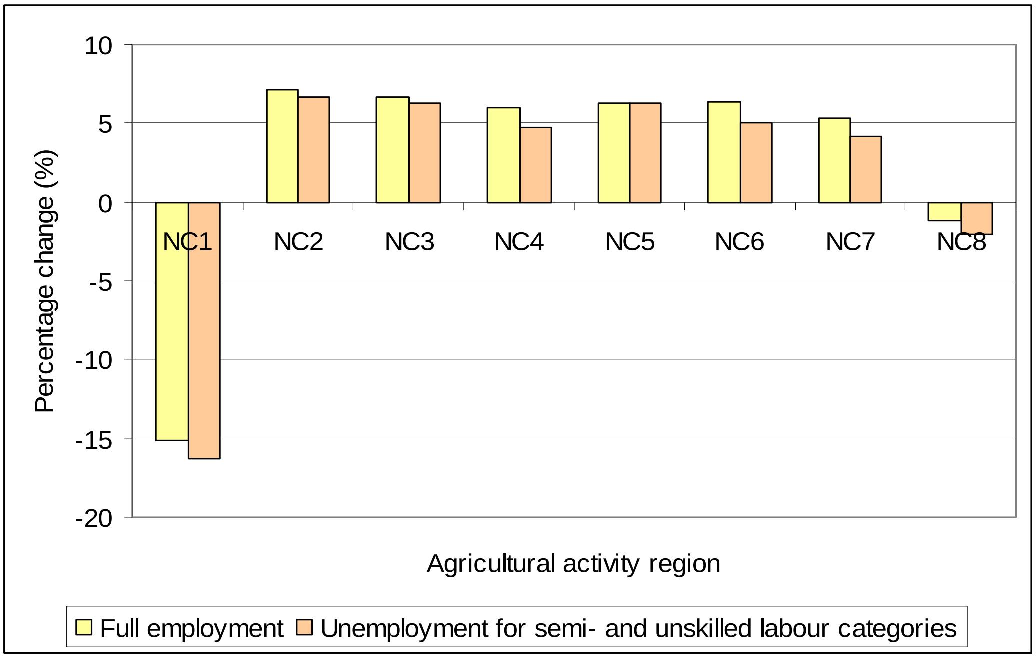


Figure 5.12: Returns to Northern Cape land under full and unemployment scenario (WFDISTXP)

A fundamental reason why the return to land in the major fruit producing regions declines can be ascribed to factor market closures used (PROVIDE, 2005). As explained earlier, land is specified as immobile yet fully employed, whereas the other production factors (capital and labour) are mobile, i.e. free to relocate. As these mobile factors relocate between sectors, the factor intensity ratio change is such that relatively more land compared to capital and labour is used, hence the return to land decreases.

5.2.4 Socio (household) and welfare impacts

Household (HH) expenditure in the economy is determined by the income HHs earn from the production factors (land, capital and labour) they own. The version of the PROVIDE SAM used for this modelling exercise includes 39 HH categories (see Table 5.5 for the HH categories in the NCP and Appendix 4A for a complete list of HH categories and corresponding abbreviations for the rest of the RSA) classified per province as well as the level of education of the head of the HH. Resulting from the world fruit price shock, 18% (7 out of 39) of the national HH categories increased their consumption expenditure with an average increase of 0.18% for both the full employment and unemployment labour scenarios. These HH are mainly not directly involved in the fruit industry, and therefore benefits from the decrease in the fruit price. The average decreases in HH consumption expenditure for the remaining 32 HH categories are 0.3% for the full employment and 0.42% for the unemployment labour scenarios.

Table 5.5: Description of the NCP household categories

Household group	Description (race group and income level)
HNC1	Northern Cape African Primary and lower
HNC2	Northern Cape African Lower Secondary and higher
HNC3	Northern Cape Coloured and Asian Lower Secondary and lower
HNC4	Northern Cape Coloured and Asian Upper Secondary and higher
HNC5	Northern Cape White

Five HH categories are distinguished for the NCP in the SAM, labelled HNC1 to HNC5, of which two categories represent Africans and coloured people respectively and one category for white HH (see Figure 5.13). The population distribution of the households residing in the NCP, as grouped in Table 5.5, is shown in Figure 5.14. African HHs (HNC1 and HNC2) represent nearly 36% of the total NCP households, whereas coloured HHs represents more than half (51.2%) of the NCP households.

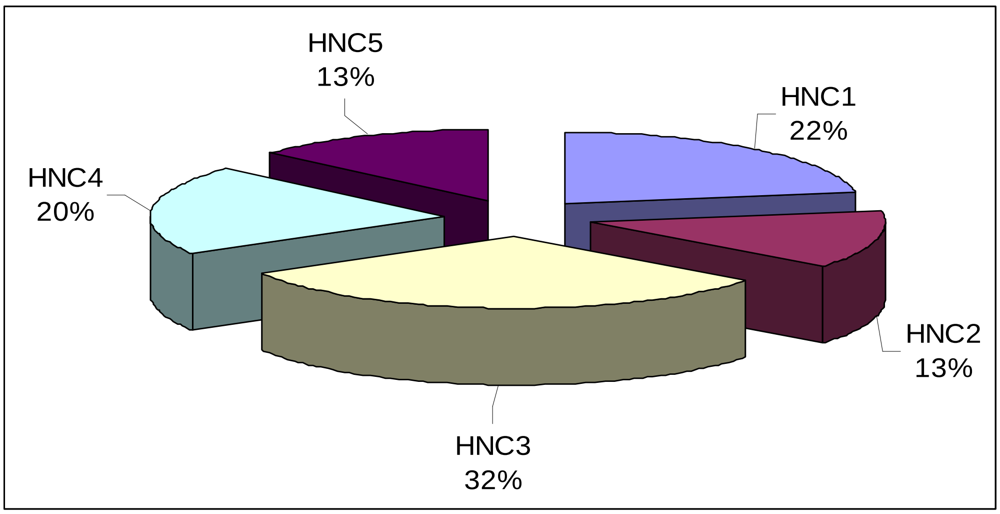


Figure 5.13: Household population distribution in the NCP
Source: PROVIDE (2005b)

More specifically, two of the seven HH groups that saw an increase in their consumption expenditure are residing in the NCP (see Figure 5.14). The average increase in HH consumption expenditure felt by NC African HHs amounts to 0.24% for the full employment and 0.11% for the unemployment scenario. The frican HH are typically not directly involved in the fruit producing regions in the NCP, and benefits therefore from lower fruit prices. The remaining three NC HH groups experienced an average decline of 0.35% and 0.63% respectively for the full employment and unemployment scenarios. It is furthermore clear from Figure 5.14 that the net welfare impact amongst all five HH categories in the NCP is negative for both employment scenarios. Despite the simulation being agriculturally orientated in nature, the effect on the provincial HH groups is representative of all HH residing in the NCP and not only those directly involved in agriculture. The specific HHs that are affected within a particular group might be those directly involved in the fruit industry.

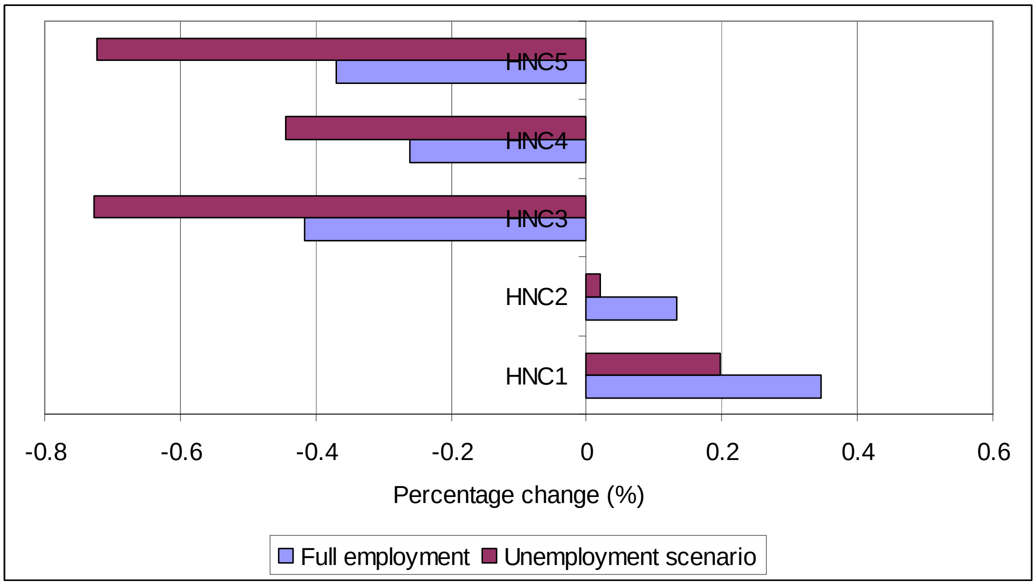


Figure 5.14: Household consumption expenditure (EHXP) for full employment and unemployment scenarios

According to Gohin (2003), one of the main tasks of applied economists is the computation and explanation of the welfare effects of policy reform or other shocks to the economy that may be of interest. The effects of the simulated results on household welfare in the NCP can further be measured by the concept of Equivalent Variation (EV). EV is a welfare measure indicating the money equivalent the HH is better (worse) off as a result of the shock/simulation (Macdonald *et al.*, 2003). Figure 5.15 illustrates the welfare impact the decrease in the world fruit price has on the households in the NCP by means of the EV coefficient. In total, HHs residing in the NCP are R 31 million worse off as a result of the fruit price shock, which is the net result of a R 3.6 million increase in the total welfare of NC African HHs and the R 34.6 million decline in the welfare of the NC Coloured and White HHs.

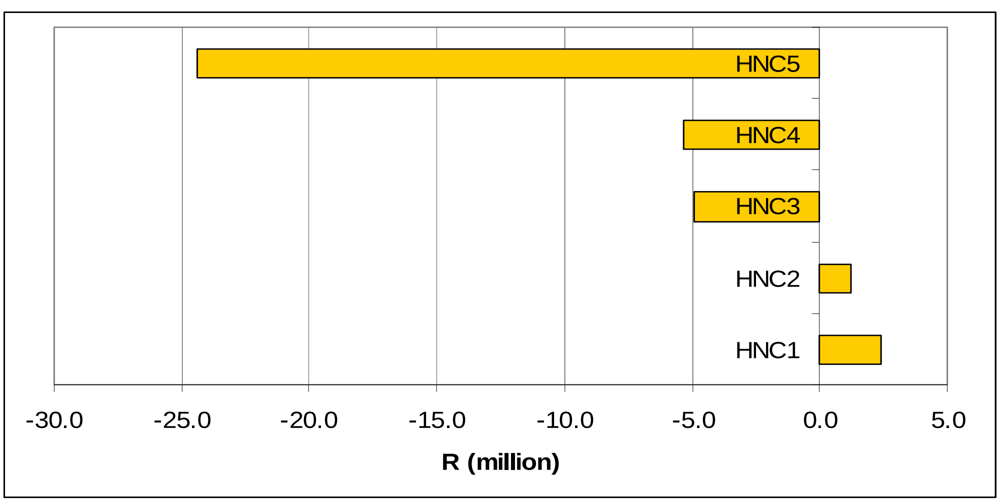


Figure 5.15: Equivalent variation (EV) for the NCP HHs

5.2.5 Government effects

The effects of the fruit price simulation on government income, expenditure and savings are reported in Table 5.5. In the case of the full employment scenario (PWDECR), the larger government deficit or (dis-) savings comes as a result of the larger decrease in government income (-0.13%) compared to the decrease in government expenditure (-0.08%). In the case of the unemployment scenario (PWEDECUE), government income decreases even further (i.e. 0.2%) and with government expenditure being equal for both employment scenarios (i.e. a 0.08% decrease), government deficit increases to 1.12% compared to the base (initial equilibrium).

Table 5.6: Government finance

Government finance	Base value (R millions)	Simulation change (% from base)	
		PWEDECR	**PWEDECRUE**
Government income	R 214,002	-0.13%	-0.20%
Government expenditure	R 234,296	-0.08%	-0.08%
Government deficit	-R 20,294	0.40%	1.12%

5.3 CONCLUSION

In this chapter, the simulated results of the PWEDECR simulation under a full employment vs. an unemployment scenario analysis were reported. In terms of the agricultural activities in the NCP, the fruit output of NC1 and NC8 is the most affected mainly due to the relatively large share of fruit in terms of total agricultural production. A similar decrease is observed in terms of the activity outputs of other provinces, including Eastern Cape, Limpopo and Mpumalanga, which also produce a significant amount of fruit. Likewise the activity value added effect for these activities declined by 7% to 15%. In addition the value added of secondary activities, fruit as well as beverages and tobacco, decreases by R 34.4 million and R 227.9 million respectively.

In terms of the commodity price effects, the prices of winter cereals, as in the case of the fruit price, decrease by approximately 2%. The prices of the other commodities increase by 0.15% in the case of other horticulture and 3% in the case of potatoes and vegetables.

The economic factors of production are also significantly affected by the shock. In terms of employment, the employment of African unskilled and semi-skilled labour categories is the only category that is (marginally) positively affected by the shock. It is important to remember that the CGE model used is a static model, i.e. represents a snapshot of the economy after it returned to equilibrium resulting from the shock. Despite the fact that employment of African unskilled and semi-skilled labour categories increases marginally, it is by far offset by the negative impacts on the other labour categories, i.e. a negative net impact on employment as a whole. A further possible explanation for this may lie in the population demographics. In the

NCP for example, the labour demand by NC1 and NC8 declined by 19% and 2.4% respectively for the unemployment scenario. In this regard it is also important to remember that only 35% of the NC population are Africans whereas only 30% of Africans are classified as agricultural workers, of which nearly 60% resides in the Francis Baard (including the city of Kimberley) district municipality whereas only 2.8% of all Africans in the NCP lives in the Namakwa district municipality (IES, 2000). From this it is clear that Africans doesn't form the majority population group in the NCP, and are specifically ill represented in the major fruit producing regions of the NCP. When the international price of fruit decreases and the profitability of exports therefore becomes less profitable, it is likely that more locally produced fruit will be sold domestically, with the closest major metropolitan being Kimberly. It can therefore be anticipated that given this lower international fruit price scenario, more fruit will flow to the informal trade in the larger metropolitan regions, where hawkers and streets vendors play an important role in offsetting these produce.

Factor demand by activity is again closely influenced by the commodities produced by the specific activity. Conversely, the labour demand in the other six NCP agricultural activities increases on average by 6.7% for all labour categories present. The Equivalent Variation (EV), which measures the money equivalent, the HHs is better (or worse in this case) off as a result of the shock/simulation, shows that HHs in the NCP loose R 31 million in total. However, white HHs lose R24.4 million and coloureds lose R 10.3 million in total, whereas African HHs gain a net of R 3.7 million. The gain by the African HHs is thus by far offset by the negative impact experience by the White and Coloured HHs.

It is furthermore clear from the simulated results that both winners and loser exist in the economy. The economy-wide impacts illustrate that the positive impacts (winners) are by far offset by the negative impacts felt by the losers as a result of the decrease in the world fruit price.

CHAPTER 6

ECONOMIC MULTIPLIERS FOR THE NORTHERN CAPE PROVINCE

6.1 INTRODUCTION 137
6.2 RESULTS OF THE MULTIPLIER ANALYSIS 137
6.2.1 Labour multipliers 138
6.2.2 Production multipliers 140
6.2.3 Value-added multipliers 142
6.3 BOTTOM-UP LINKAGES – APPLYING THE ECONOMIC MULTIPLIERS TO THE REGIONAL MODEL SIMULATIONS 143
6.3.1 Regional economic modelling framework and scenarios 144
6.3.2 Bottom-up effects of micro-economic scenarios 145
6.3.2.1 Labour impacts 145
6.3.2.2 Production impacts 147
6.3.2.3 Value-added impacts 148
6.4 CONCLUSIONS 149

LIST OF TABLES

TABLE 6.1: LABOUR MULTIPLIERS 139
TABLE 6.2: PRODUCTION MULTIPLIERS 141
TABLE 6.3: VALUE-ADDED MULTIPLIERS 143
TABLE 6.4: SELECTED MICRO-ECONOMIC SCENARIOS AND CORRESPONDING MACRO-ECONOMIC LABOUR IMPACTS 146
TABLE 6.5: PRODUCTION EFFECTS OF SELECTED MICRO-ECONOMIC SCENARIOS 147
TABLE 6.6: VALUE-ADDED EFFECTS OF SELECTED MICRO-ECONOMIC SCENARIOS 148

CHAPTER 6

ECONOMIC MULTIPLIERS FOR THE NORTHERN CAPE PROVINCE

6.1 INTRODUCTION

In addition to the simulated results obtained from the CGE model, economic multipliers can also be used to estimate the likely economy-wide impacts of simulated changes/shocks imposed at micro-economic level. As explained in Chapter 4, one needs to keep the key assumptions (i.e. fixed relative prices and perfect elastic supply) of economic multipliers in mind when interpreting projected effects based on such an analysis. Miller (1996) cautions that when interpreting multipliers, it should always be kept in mind that multipliers, in essence, are simple ratios. Economic multipliers only provide estimates of the total impact resulting from an initial change in economic output (i.e. final demand). It is furthermore also important to remember that multipliers vary extensively from one industry to another. This depends, however, on where production input purchases are made in a specific industry or activity. Using the average multiplier for an industry may therefore overestimate or underestimate the real impact on a specific industry (Miller, 1996).

The next section reports on the economic multipliers calculated. This is followed in the third section by an application of the multiplier effects to selected micro-economic simulation(s) results as analysed by in the regional economic model discussed by Louw *et al.* (2007). A summary and conclusion is given in the fourth section.

6.2 RESULTS OF THE MULTIPLIER ANALYSIS

Three types of economic multipliers (as described in more detail in Chapter 4 and shown in Table 6.1 to Table 6.3 below) were calculated based on the PROVIDE SAM (Provide, 2005b) used as the macro-economic database in this study. For each of the three groups of multipliers the direct, indirect and induced multiplier effects are calculated. In addition to these effects, the additions of the direct and indirect multipliers as well as the total effects (i.e. direct, indirect, as well as induced effects) are also reported in the corresponding tables.

As also reported in Chapter 2, Conningarth (2005) explains that the **direct impacts** are those impacts that emanate in a particular sector itself. **Indirect impacts** in turn reflect the impacts that a particular sector will have on all other input-supplying industries, whereas the **induced**

impacts will result from the paying out of salaries and wages to people employed in a particular activity, as well as other activities/sectors indirectly linked to the first activity. In the subsequent three subsections, the **labour, production** and **value-added** multipliers for agricultural activities in the NCP, as well as for other (rest of the economy) aggregated production activities in the South African economy, are reported and interpreted.

6.2.1 Labour multipliers

Labour multipliers or employment creation are key elements in any production process, especially in labour-intensive sectors like agriculture. Conningarth (2005) explains that this indicator measures job creation and indicates the extent to which each sector contributes towards the creation of employment opportunities and, ultimately, each sector's contribution towards distributing salaries and wages amongst various types of labourers which, in turn, should impact positively on the alleviation of poverty.

Table 6.1 depicts the labour multipliers calculated for the economic activities in the South African economy. Amongst the economic activities shown, as in the case of the other three sets of multipliers below, are the disaggregated details for the eight agricultural activities (i.e. NC1 through NC8) in the NCP. More specifically, the labour multipliers provide an indication of the number of full-time job (FTJ) opportunities created per R1 million production of a particular activity.

In terms of agriculture in the NCP, De Aar Karoo (NC4), Kgalagadi (NC5) and Kimberly (NC8) have the largest **direct labour multipliers**. The reported direct labour multipliers of 15.6 for NC4 and 15.4 for NC5 and NC8 respectively indicate that for each R1 million of agricultural output/production from any one of either NC4, NC5 or NC8, 15.6 or 15.4 full-time agricultural job opportunities respectively are created within the respective sector. The direct labour multipliers for the other NC agricultural activities range between 11.9 (NC6) and 15.6 (NC4). The direct labour multipliers for the other aggregate economic activities range from a low of 1.7 in the case of communication and electricity, water and gas to a high of 91.3 in the case of domestic services.

The **indirect multipliers,** listed in the third column of Table 6.1, measure the impact (backward linkage) that a particular sector will have on all other industries that supply inputs to that particular sector – more specifically the indirect labour multipliers, which provide an indication of the full-time job opportunities created in the input-supplying sector as a result of a R1 million increase in the original sector. From Table 6.1 it is apparent that the indirect labour multipliers for economic activities in the NCP range between 2.1 in the case of NC1 and 3.5 in the case of NC5. Compared to agricultural activities in the other eight provinces, the average indirect multiplier of 3 for the NCP is slightly below the national average of 3.5, with a maximum of 4.7 in the case of Gauteng agriculture. The indirect labour multiplier for national agriculture as a whole is similar to that of all economic activities with an average of 3.7. However, the other economic activities range from 0 in the case of domestic services (as there are no inputs supplied in this sector) to 6.5 in the case of manufacturing.

Table 6.1: Labour multipliers

Activities	Multipliers				
	Direct	**Indirect**	**Direct + Indirect**	**Induced**	**Total**
Western Cape Agriculture	15.1	3.4	18.5	7.7	26.2
NC Agric Namakwaland (NC1)	13.4	2.1	15.5	10.1	25.6
NC Agric Sutherland Karoo (NC2)	14.7	3.3	18.0	9.7	27.7
NC Agric Victoria West Karoo (NC3)	13.7	3.5	17.2	9.8	27.0
NC Agric De Aar Karoo (NC4)	15.6	2.8	18.4	10.4	28.8
NC Agric Kgalagadi (NC5)	15.4	3.5	18.9	8.8	27.7
NC Agric Carnarvon Karoo (NC6)	11.9	2.5	14.4	10.4	24.8
NC Agric Frances Baard (NC7)	14.0	3.4	17.4	9.8	27.2
NC Agric Kimberley (NC8)	15.4	3.2	18.5	10.3	28.9
Eastern Cape Agriculture	35.0	3.3	38.4	9.3	47.6
KwaZulu-Natal Agriculture	31.8	3.5	35.3	8.9	44.2
Limpopo Agriculture	18.2	3.4	21.6	8.8	30.4
North West Agriculture	10.9	4.1	15.0	8.5	23.5
Free State Agriculture	11.4	4.6	15.9	7.4	23.3
Mpumalanga Agriculture	11.5	4.2	15.7	7.0	22.7
Gauteng Agriculture	7.2	4.7	11.9	6.8	18.7
Forestry & Fishing	8.7	4.5	13.2	6.2	19.4
Construction	7.2	6.4	13.6	7.5	21.0
Trade & Accommodation	10.2	3.5	13.7	7.7	21.4
Transport Services	4.2	4.6	8.8	7.0	15.7
Communication	1.7	3.8	5.5	6.0	11.5
Business Services	3.1	3.1	6.2	7.0	13.2
Government, Health & Social	7.3	2.9	10.2	10.3	20.5
Activities & Services	25.6	4.7	30.2	9.7	40.0
Domestic Services	91.3	0.0	91.3	14.0	105.3
Mining Activities	4.4	4.2	8.6	7.1	15.7
Manufacturing Activities	2.5	6.5	8.9	6.1	15.1
Electricity, Water & Gas	1.7	3.5	5.3	5.9	11.2
Weighted Total	5.9	4.6	10.5	7.3	17.8

The **induced effects** measure the economic impact that will result from salaries and wages paid out to employees in both the particular or direct activity and the input-supplying sectors. Conningarth (2005) explains that these additional salaries and wages lead to an increased demand for various consumable goods that need to be supplied by various economic activities throughout the broader economy. In the NCP the observed induced effects range from 8.8 in the case of NC5 to 10.4 for NC4 and NC6 respectively. This is similar in magnitude to agricultural activities (measuring 9 on average) in the other eight provinces, as well as the other economic sectors (measuring 8.5 on average for the economy as a whole). From the results it is clear that the induced effects are on average double the size of the indirect effects and only slightly smaller than the direct effects.

The sum of the direct, indirect and induced effects provides an indication of the **total employment effects** resulting from a R1 million change in agricultural production. In the case of NC8, almost 29 full-time job opportunities are created on average as a result of a R1 million change in agricultural production. The smallest total labour multiplier for NCP agricultural activities is Carnarvon Karoo (NC6) with 24.8, whereas the average total multiplier for all economic activities is 27.3, with the weighted total (see final row in Table 6.1) in terms of total activity output/production being 17.8.

Within the NCP, when comparing the different agricultural activities, one typically tends to think that the regions with intensively irrigated agriculture (i.e. fruit and table grapes for example) will have a higher labour multiplier. However, this is not the case for Namakwaland (NC1), which includes the Lower Orange River. Despite the fact that these intensive agricultural production activities employ a large number of workers, high-value products are typically produced. The higher production value therefore diminishes the size of the direct labour multiplier, i.e. total employment divided by production. The production/output per labourer employed is therefore higher in these sectors. A second factor with an influence is the fact that the labour multiplier, as calculated, measures full-time employment. These labour-intensive activities typically employ a significant number of part-time seasonal workers, which further diminishes the magnitude of the direct labour multipliers.

6.2.2 Production multipliers

Conningarth (2005) explains that the economic term “production” refers to the total turnover (i.e. quantity produced multiplied by the corresponding price) generated by each activity/sector in the economy, which can be measured as the sum of the intermediate inputs plus the total value added by a specific sector.

The production multipliers (i.e. direct, indirect and induced effects) for economic activities are shown in Table 6.2. It is clear from the second column that because it is the production multiplier that is calculated, the direct multipliers equal 1 (i.e. production divided by itself). At 0.72 the indirect multiplier for NC3 and NC5 is the largest for all agricultural activities in the NCP. This implies that a R1 increase in production in any of these two sectors will have a backward effect of R0.72 (i.e. increase in sales) on the economic sector supplying inputs to any of these sectors. The induced effects of the two sectors amount to 1.48 and 1.3 respectively, indicating that as a result of the additional salaries and wages paid out due to the original R1 increase in production in the two agricultural sectors (NC3 and NC5), increased consumer spending totalling

R1.48 and R1.3 respectively will result. Together the total production multipliers for NC3 and NC5 add up to R3.12 and R3.02 respectively.

Table 6.2: Production multipliers

Activities	Multipliers				
	Direct	Indirect	Direct + Indirect	Induced	Total
Western Cape Agriculture	1	0.68	1.68	1.22	2.89
NC Agric Namakwaland (NC1)	1	0.45	1.45	1.45	2.91
NC Agric Sutherland Karoo (NC2)	1	0.68	1.68	1.43	3.12
NC Agric Victoria West Karoo (NC3)	1	0.72	1.72	1.48	3.19
NC Agric De Aar Karoo (NC4)	1	0.56	1.56	1.50	3.06
NC Agric Kgalagadi (NC5)	1	0.72	1.72	1.30	3.02
NC Agric Carnarvon Karoo (NC6)	1	0.51	1.51	1.50	3.01
NC Agric Frances Baard (NC7)	1	0.66	1.66	1.41	3.07
NC Agric Kimberley (NC8)	1	0.62	1.62	1.49	3.11
Eastern Cape Agriculture	1	0.66	1.66	1.41	3.07
KwaZulu-Natal Agriculture	1	0.70	1.70	1.40	3.10
Limpopo Agriculture	1	0.69	1.69	1.29	2.97
North West Agriculture	1	0.79	1.79	1.26	3.05
Free State Agriculture	1	0.89	1.89	1.11	3.00
Mpumalanga Agriculture	1	0.83	1.83	1.09	2.91
Gauteng Agriculture	1	0.89	1.89	1.09	2.97
Forestry & Fishing	1	0.92	1.92	0.98	2.90
Construction	1	1.27	2.27	1.18	3.45
Trade & Accommodation	1	0.81	1.81	1.20	3.01
Transport Services	1	0.99	1.99	1.09	3.08
Communication	1	0.88	1.88	0.93	2.81
Business Services	1	0.73	1.73	1.08	2.81
Government, Health & Social	1	0.59	1.59	1.63	3.22
Activities & Services	1	0.96	1.96	1.51	3.48
Domestic Services	1	0.00	1.00	2.34	3.34
Mining Activities	1	0.86	1.86	1.11	2.98
Manufacturing Activities	1	1.28	2.28	0.96	3.24
Electricity, Water & Gas	1	0.86	1.86	0.92	2.78
Weighted Total	1	0.96	1.96	1.14	3.10

The total production multipliers for agricultural activities in the NCP compare well with the agricultural activity production multipliers of the remaining eight provinces. The average production multiplier for NCP agricultural activities (3.06) is for all practical purposes equal to the average of 3 as calculated for agriculture in the remaining eight provinces. The lowest total production multiplier in the NCP, i.e. 2.91 for NC1, is very similar to the calculated total production multiplier of 2.89 for Western Cape agricultural activities. In the case of the maximums, NC3 amounts to 3.19 compared to the average of 3.1 for agriculture in the remaining eight provinces, which also happens to be the same for the weighted (in terms of total production) total production multiplier for all economic activities.

6.2.3 Value-added multipliers

Gross domestic product (GDP) is defined as the sum of the value added of all the sectors in an economy. Value added is therefore a measure of the value that is added to each product produced in an economy by the various economic sectors at each stage in the production process (Conningarth, 2005). Value added for a specific sector is calculated as the difference between the revenue earned by the sector and the amount it pays for the products of other sectors that it uses as intermediate goods in the production process. As such, value added consists of three elements, namely:

- Remuneration of employees
- Gross operating surplus (which includes profits and depreciation)
- Net indirect taxes

The value-added multipliers calculated for the economic activities from the SAM are shown in Table 6.3. In terms of agricultural activities in the NCP, on average R630 000 worth of value is added to every R1 million of sectoral agricultural production (not shown in the table), whereas the weighted average in terms of total production amounts to R490 000 (see last row of Table 6.3). More specifically in the case of agriculture in the NCP, with regard to NC1 (i.e. the region that includes the Lower Orange River) R728 000 (shown as 0.73 in the table) of direct value and R170 000 of indirect value is added (in input-supplying industries) as a result of R1 million worth of primary agricultural production in the NC1 region. Given an induced effect of R630 000 (i.e. increased consumer spending resulting from the increases in salaries and wages paid in the specific sector as well as the input-supplying sector), the total value-added multiplier for NC1 amounts to R1 530 000. In more direct terms, R1 million worth of primary production in NC1 results in R1.53 million worth of additional value added.

The average total value-added multiplier for agricultural activities in the NCP (1.49) is slightly higher compared to the national average value-added multiplier of 1.42 for national agricultural activities (not shown in table).

Compared to the other economic sectors, agriculture is above average, with the lowest value-added multiplier being 1.1 in the case of manufacturing activities and the highest (with the exception of 1.96 in the case of domestic services, which only consist of value added) being 1.58 for government, health and social services. The weighted total (in terms of original value added per activity) for all economic activities amounts to 0.49 direct, 0.35 indirect and 0.51 induced, resulting in a total weighted value-added multiplier of 1.35. These figures imply that on average (weighted in terms of original value added) a R1 million change (increase) in economic output will result in an additional R490 000 worth of direct value added, R350 000 worth of inputs required (backward linkages) and R510 000 worth of additional consumer spending resulting from the additional salaries and wages that are paid out to employees in the economy.

Table 6.3: Value-added multipliers

Activities	Value-added multipliers				
	Direct	**Indirect**	**Direct + Indirect**	**Induced**	**Total**
Western Cape Agriculture	0.59	0.25	0.85	0.51	1.36
NC Agric Namakwaland (NC1)	0.73	0.17	0.90	0.63	1.53
NC Agric Sutherland Karoo (NC2)	0.59	0.26	0.85	0.61	1.46
NC Agric Victoria West Karoo (NC3)	0.57	0.28	0.85	0.63	1.48
NC Agric De Aar Karoo (NC4)	0.66	0.21	0.88	0.65	1.53
NC Agric Kgalagadi (NC5)	0.57	0.27	0.84	0.56	1.40
NC Agric Carnarvon Karoo (NC6)	0.69	0.20	0.89	0.65	1.54
NC Agric Frances Baard (NC7)	0.60	0.25	0.85	0.61	1.46
NC Agric Kimberley (NC8)	0.63	0.24	0.87	0.64	1.51
Eastern Cape Agriculture	0.60	0.25	0.85	0.59	1.44
KwaZulu-Natal Agriculture	0.58	0.26	0.84	0.58	1.42
Limpopo Agriculture	0.59	0.26	0.84	0.54	1.39
North West Agriculture	0.52	0.30	0.82	0.53	1.35
Free State Agriculture	0.46	0.34	0.80	0.47	1.27
Mpumalanga Agriculture	0.50	0.31	0.81	0.45	1.27
Gauteng Agriculture	0.46	0.33	0.79	0.46	1.25
Forestry & Fishing	0.45	0.34	0.79	0.41	1.20
Construction	0.30	0.46	0.76	0.49	1.25
Trade & Accommodation	0.52	0.35	0.87	0.51	1.37
Transport Services	0.41	0.40	0.80	0.46	1.26
Communication	0.47	0.35	0.83	0.39	1.22
Business Services	0.56	0.33	0.89	0.46	1.35
Government, Health & Social	0.64	0.25	0.90	0.68	1.58
Activities & Services	0.42	0.40	0.82	0.64	1.46
Domestic Services	1.00	0.00	1.00	0.96	1.96
Mining Activities	0.49	0.34	0.83	0.47	1.29
Manufacturing Activities	0.22	0.48	0.70	0.40	1.10
Electricity, Water & Gas	0.50	0.36	0.85	0.39	1.24
Weighted Total	0.49	0.35	0.84	0.51	1.35

6.3 BOTTOM-UP LINKAGES – APPLYING THE ECONOMIC MULTIPLIERS TO THE REGIONAL MODEL SIMULATIONS

Louw *et al.* (2007) developed a regional-level model to quantify the impact of market risk on efficient use of irrigation water with specific reference to the NCP. More specifically, these models aimed to develop a decision-making framework to be used by farmers to reduce their risk and also to compare present water use practices with optimal risk-reducing practices and to find reasons for deviations from the optimum.

In order to illustrate the bottom-up (micro-economic to macro-economic) effects, the simulated results of the selected micro-economic scenarios specified are used in the subsequent section, together with the calculated multipliers, to show the macro-economic impacts of these scenarios.

6.3.1 Regional economic modelling framework and scenarios

Louw *et al.* (2007) explain that the typical farms compiled are the primary production units within the sub-regional modelling framework, and the sub-regional model is therefore an aggregation of the typical farms. The Orange River regional model in turn is an aggregation of the sub-regional models. Louw *et al.* (2007) employed a dynamic linear programming modelling framework, with the objective function solved over the total planning horizon (i.e. 20 years).

As in Chapter 5, linked to the overall objective to quantify the economic impact of market risk, various scenarios (15 in total) relating to the table grape industry were formulated and used to show the effect on the NCP regional model (Louw *et al.,* 2007). Louw *et al.* (2007) furthermore explain that the base situation is characterised by the (at that stage) prevailing land use patterns with no water trade allowed. In addition a 20% downward variation in long-term crop area, a 100% upward and 50% downward variation in short-term crop area were also allowed.

The 15 scenarios specified by Louw *et al.* (2007) can be grouped into four sets for simplification, including:

- Set 1: This is the base scenario (existing land use) plus scenarios 1 to 3 where table grape prices are reduced and only very limited structural change is possible. The only reason for the limited change is that the aggregation factors are based on existing water use rights, which are not necessarily all in use.
- Set 2: This set includes base B and scenarios 4 to 7. Scenarios 4 to 6 are the same as scenarios 1 to 3, with the exception that for base B, a greater variation (60% instead of the initial 20%) from the base long-term crop area is allowed. Scenario 7 is analysed to determine the maximum reduction in table grape prices just before unfeasibility.
- Set 3: This set includes base C and scenarios 8 to 10. These scenarios are exactly the same as the scenarios for set 1, but water trade is allowed.
- Set 4: This set includes base D and scenarios 11 to 15. These are exactly the same as the scenarios for set 2, but water trade is allowed.

The three scenarios specified in each set are characterised by a respective 10%, 20% and 25% reduction in the price of table grapes. In terms of the simulated results, Louw *et al.* (2007) analyse the impact on the following variables:

- Changes in the aggregated objective function value, i.e. the net output of Northern Cape irrigated agriculture;
- Average net farm income per region per annum and changes from the base analysis;
- Structural changes per region compared to the base analysis;
- Total average land use (area) per region;
- Total and per-hectare water usage;
- Capitalised return on capital investment;

- Average marginal value of water; and
- Water trade between regions.

The changes in the aggregate objective function value (net output of NCP irrigated agriculture) is used in the following section to illustrate the macro-economic impacts by means of the calculated economic multipliers.

6.3.2 Bottom-up effects of micro-economic scenarios

The macro-economic labour or employment, production and value-added impacts resulting from four selected scenarios (i.e. regional scenarios 2, 5, 9 and 12 in Louw *et al.,* 2007) investigated on a regional economic level are discussed in the following three subsections. These four scenarios are all characterised by a 20% reduction in the price (producer or farm-gate price) of table grapes, whereas they differ in terms of the variation allowed in area produced, as well as water trade. Scenario 2 is the same as the base with a 20% deviation allowed in long-term crop area, whereas scenario 5 represents a 60% permitted deviation in the long-term crop area. Scenarios 9 and 12 are respectively the same as scenarios 2 and 5 above, but with water trade allowed.

6.3.2.1 Labour impacts

The objective values over 20 years for selected scenarios from the regional (micro-economic) model are shown in the second row of Table 6.4. (These figures are taken from Table 7.11 and Table 7.12 in Louw *et al.,* 2007). The third and fourth columns respectively show the annual objective value and the change in the annual objective value. From the table it is clear that the objective function value for the base amounts to R25 277 million, which according to Louw *et al.* (2007) represents the net irrigated output of the Northern Cape over the 20-year planning horizon. The fourth row shows the change in the objective function values for the selected four scenarios. In the case of scenario 2, for example, the change in the net annual output from irrigation agriculture as a result of the 20% decrease in the price of table grapes amounts to R947 million.

The second part (last six rows) of Table 6.4 reports on the macro-economic (economy-wide) labour impacts for the NCP resulting from the micro-economic scenarios under discussion. These effects (direct, indirect and induced) are calculated by multiplying the micro-economic scenario results with the corresponding weighted average labour multiplier of agricultural activities (NC1 to NC8) in the NCP. The macro effects shown in the base column therefore represent the corresponding employment figures resulting from the baseline output for irrigation agriculture in the NCP as calculated by the labour multipliers. According to the annual R1 264 million output from irrigation agriculture in the NCP (from the micro-economic model), 17 828 full-time jobs are created within irrigation agriculture within the NCP, which leads to an additional 3 580 full-time job opportunities in the industries supplying production inputs to irrigation. In terms of the induced effects, a further 12 547 full-time jobs are created as a result of the demand for consumables created from the wages and salaries paid out in the direct and indirect sectors. The total employment effect therefore adds up to 33 955 full-time jobs created from the R1 264 million worth of output in irrigated agriculture in the NCP.

Table 6.4: Selected micro-economic scenarios and corresponding macro-economic labour impacts

Model level	Variable	Scenario (20% reduction in table grape price)				
		Base	Scenario 2	Scenario 5	Scenario 9	Scenario 12
Regional (micro) model	Objective function: 20 years (R million)	25,277	18,946	26,236	20,094	27,374
	Objective function: Annual (R million)	1,264	947	1,312	1,005	1,369
	Change in annual objective value (R million)	-	-316.55	47.95	-259.15	104.85
Macro (Labour multiplier)	Direct	17828	-4465	676	-3656	1479
	Indirect	3580	-897	136	-734	297
	Direct + Indirect	21408	-5362	812	-4390	1776
	Induced	12547	-3143	476	-2573	1041
	Total	33955	-8505	1288	-6962	2817
	% Change in total	-	-25%	4%	-21%	8%

Source: Louw *et al.* (2007) and own calculations

Columns 4 to 7 show the labour impacts resulting from the scenarios analysed by the regional model (Louw *et al.,* 2007). As mentioned above, scenario 2 is characterised by a 20% reduction in the (producer) price of table grapes, with no water trade allowed and a 100% upward and 50% downward variation in the short-term crop area over the planning horizon. This results in a 33% or R316 million decrease in the objective value or output from regional irrigation agriculture. From the latter part of Table 6.4 it is clear that as a result of this decrease in output, a total of 8 505 full-time jobs are lost, consisting of 4 465 farm-level jobs, 897 input-supplying industry-level jobs, and 3 143 induced job opportunities.

According to Louw *et al.* (2007) scenario 5 is also characterised by a 20% decrease in the price of table grapes, but a 60% variation (upward and downward) in the long-term crop area is allowed from the base. Louw *et al.* (2007) explain that when restrictions on land use patterns are reduced, the objective value increases. However, Louw *et al.* (2007) also caution that the new land use patterns provided by the regional model are not necessarily practical and require more analysis, since the model is not an exact replica of the real world (the model does not necessarily consider all the restrictions faced by farmers). Subsequently, scenario 5 results in a 3.8% (R47.9 million) increase in the annual objective function value from the base, which in turn transforms into an additional 1 288 full-time jobs created when applying the labour multiplier calculated for the agricultural activities in the NCP.

Scenario 9 is specified exactly the same as scenario 2, with the only difference being that water trade is allowed. Due to the water trade (i.e. compared to scenario 2) the effect on the objective value is less severe with a 20.5% (R259 million) decrease. Likewise, this 20.5% decrease represents in total 6 962 full-time employment opportunities. The last scenario shown, scenario 12, is again similar to scenario 5, with the only difference being the possibility of water trade. Despite the 20% decrease in the price of table grapes, the annual objective function value increases by 8.3% (representing 2 817 full-time jobs) due to the allowance of water trade and variation in crop areas.

6.3.2.2 Production impacts

Table 6.5 reports on the macro-economic production impacts of selected micro-economic scenarios. The same regional farm-level scenarios, i.e. 2, 5, 9 and 12, are used to illustrate the macro-economic effects on production, as well as on value added. As in the case of labour impacts, the multipliers calculated are used to estimate the macro-economic impacts on the NCP.

From the third column of Table 6.5 it is clear that the R1 264 million output from irrigation agriculture in the NCP results in additional indirect production to the value of R778 million and an induced production demand of R1 827 million, aggregating to a total production (output) of R3 869 million. These production multiplier effects are then multiplied by the resulting scenario changes in irrigated agricultural output, as shown by the micro-economic model, to estimate the macro-economic impacts (shown in columns 4 to 7).

Table 6.5: Production effects of selected micro-economic scenarios

		Scenario (20% reduction in table grape price)				
Model level	Variable	Base	Scenario 2	Scenario 5	Scenario 9	Scenario 12
Regional (micro) model	Objective function: 20 years (R million)	25,277	18,946	26,236	20,094	27,374
	Objective function: Annual (R million)	1,264	947	1,312	1,005	1,369
	Change in annual objective value (R million)	-	-316.6	48.0	-259.2	104.9
Macro (production) effect	Direct	1264	-317	48	-259	105
	Indirect	778	-195	30	-160	65
	Direct + Indirect	2042	-512	77	-419	169
	Induced	1827	-458	69	-375	152
	Total	3869	-969	147	-793	321

Source: Louw *et al*. (2007) and own calculations

In the case of scenario 2, total production decreases by R969 million as a result of the 20% decrease in the farm-gate price of table grapes. When water trade is allowed the impact is less severe, with an observed decline in total economic output of R793 in the case of scenario 9. An increase in total production (R147 million) can be expected when structural adjustments are allowed in long-term irrigated agricultural crops in the case of scenario 5, whereas the same scenario – together with the possibility of water trade – results in a R321 million increase in total economic output. The corresponding indirect and induced effects for the corresponding scenarios can also be seen in the table.

6.3.2.3 Value-added impacts

As in the case of production effects, shown in the previous section, Table 6.6 reports on the direct, indirect and induced value-added effects on the NCP as well as the rest of the RSA economy. The base column in Table 6.6 illustrates the macro-economic value-added effects resulting from agricultural production in the NCP. On average, the R1 264 million increase in irrigated agricultural output results in R796 million worth of direct value added, R298 million worth of indirect value added and R786 million worth of induced value added, indicating that each R1 worth of production leads to an additional R1.88 worth of value added.

The macro-economic value-added impacts for the four micro-economic scenarios are shown in columns 5 to 7. As in the case of all other results explained thus far, it is clear that the ability of farmers to trade irrigation water results in a nearly R100 million improvement in agricultural and related value added. However, when the model allows structural adjustments in terms of crop areas, the impact is significantly greater with an improvement of over R540 million in total value added in both cases (i.e. scenarios 5 and 12).

Table 6.6: Value-added effects of selected micro-economic scenarios

Model level	Variable	Scenario (20% reduction in table grape price)				
		Base	Scenario 2	Scenario 5	Scenario 9	Scenario 12
Regional (micro) model	Objective function: 20 years (R million)	25,277	18,946	26,236	20,094	27,374
	Objective function: Annual (R million)	1,264	947	1,312	1,005	1,369
	Change in objective value (R million)	-	-316.55	47.95	-259.15	104.85
Macro (production) effect	Direct	796	-199	30	-163	66
	Indirect	298	-75	11	-61	25
	Direct + Indirect	1094	-274	42	-224	91
	Induced	786	-197	30	-161	65
	Total	1880	-471	71	-386	156

Source: Louw *et al.* (2007) and own calculations

6.4 CONCLUSIONS

In this chapter, the results of three sets of economic multipliers (labour, production and value added) calculated from the PROVIDE SAM are calculated. These multipliers are then used to estimate the macro-economic or economy-wide impact(s) on the NCP of selected scenario results from a micro-economic model – the regional dynamic linear programming (DLP) model – developed and described in Louw *et al.* (2007). The selected scenarios are all characterised by a 20% decrease in the producer (farm-gate) price of table grapes, as well as various allowances in long-term and short-term crop areas and a water trading scenario.

The calculated indirect multipliers/effects, based on the scenario results, show the extent to which production in a specific agricultural economic sector links backward to other input-supplying economic sectors/activities in the broader economy. The induced effects in turn show the effects of additional demand created as a result of the salaries and wages paid out in the direct and indirect economic sectors. These backward linkages therefore empirically quantify and thereby also confirm the well-known economic phenomenon of interrelatedness of economic sectors. More specifically, the results measure the extent to which irrigated agricultural activities in the NCP influence other backward-related economic sectors, not only in the NCP but also in other related economic sectors.

As mentioned in the introduction to this chapter, the multipliers calculated and applied need to be interpreted with caution, mainly due to the assumptions of fixed relative prices and perfect elasticity of supply. This implies that economic multipliers are "blind" to any prices (inputs or outputs) that may change due to changes in general equilibrium (supply and demand) conditions. In terms of the perfect elasticity of supply, multipliers furthermore also ignore any supply (oversupply) constraints or conditions that an economy might be faced with as a result of expansions (contractions) in particular economic sectors.

CHAPTER 7

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION 150
7.2 SUMMARY OF FINDINGS 150
7.2.1 Economy-wide methodology 151
7.2.2 Results of the economy-wide models 152
7.3 CONCLUSIONS 155
7.4 RECOMMENDATIONS 159
7.4.1 Institutional response required 160
7.4.1.1 Farm level response 163
7.4.1.2 Industry or organized agriculture response 163
7.4.1.3 National and provincial government response 165
7.4.3 Recommendations on future research 169

CHAPTER 7

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

This study adds an economy-wide model as tool to the group of already existing DSS available to agriculture and more specifically irrigation agriculture. By simulating a decrease (20%) in the world fruit price, the economy-wide impacts on the NCP economy specifically and the national economy in general are quantified. Amongst others, the impacts on the; economic activities, commodities, factors of production, socio economic (households) and government of the NCP are quantified. In addition, national impacts are also highlighted where applicable and important.

As discussed in Chapter 1 of this thesis, this study is based on the second part of a larger project with the overall objective firstly to quantify the impact of market risk on the efficient use of irrigation water and secondly to determine the multiplier effects of irrigation agriculture accompanied by a shift in production patterns with reference to the middle and lower Orange River on the economy of the NCP. The last sub-objective of this study, which is dealt with in this chapter, include the formulation of institutional responses required, firstly to reduce risks and improve the financial viability of individual farmers and irrigation schemes and secondly on effective water management for regions where irrigation agriculture makes a major contribution to the economy such as the NCP.

A summary of the findings of this section are provided in the next section, firstly in terms of the applied methodology and secondly of the major results of the scenarios considered. In the second section, conclusions are made, whereas in the third and final section, recommendations are presented on the institutional response required to mitigate the effect of external shocks and improve the efficiency of water management as well as for future research needs.

7.2 SUMMARY OF FINDINGS

In this section, a summary is firstly provided of the economy-wide methodology used and secondly of the results from the economy-wide models.

7.2.1 Economy-wide methodology

Two types of methodologies were applied in order to reach the objective of quantifying the effect of external shocks in irrigation agriculture on the macro-economy of the Northern Cape. Firstly, in order to run selected macro economic simulations (macro economic shocks or risks), a static CGE model was calibrated to an aggregated version of a national SAM for South Africa with disaggregated detail for the agricultural activities in the NCP. The CGE model was then used in the form of a top-down approach to simulate the impacts of changes in selected macro economic (typically uncontrollable or exogenous factors for farmers, i.e. risk factors) variables like for example the world price of fruit. These impacts, quantified in terms of effects on activities, commodities, production factors, socio-economic or welfare as well as on the government, are then used as inputs in the regional economic models to analyse amongst other the impact on farm and regional level.

The CGE model used for the purpose of economy-wide analysis purposes are mainly based on the standard static IFPRI CGE model. The CGE model was calibrated to a National Social Accounting Matrix (SAM) for South Africa by the Provincial Decision-Making Enabling (PROVIDE) project. The calibration of the CGE model to the SAM implies that the base solution of the CGE model literally duplicates the original database or SAM where-after shocks or simulations can be applied with the model.

Secondly a SAM-Leontief multiplier analysis was conducted based on the same SAM, used as database for the CGE model. These calculated economic multipliers (labour, production and value added) were then used in the form of a bottom-up approach in order to measure the economy-wide impacts of selected simulated changes on the regional level (see Louw *et* al*.,* 2007).

Two key assumptions are made by typical SAM-Leontief multiplier models, including: firstly, fixed relative prices are assumed, and secondly, perfect elastic supply conditions, i.e. excess production capacity in all sectors. These assumptions lead to the central assumption in this type of analysis that sectoral production is completely demand driven and that the underlying production function assumes constant returns to scale and no substitution among the different inputs.

Despite these shortcomings, in order to estimate the macro-economic impact of simulated changes at regional (micro-economic) level, three sets of economic multiplies (i.e. labour, production and value added) are calculated from an aggregated version of the NCP SAM. For the purpose of calculating the multipliers, various accounts in the original version of the SAM described above were aggregated. In terms of commodity accounts, all non-agricultural commodities were aggregated, whereas all activities except for the agricultural activities in the

NCP were aggregated. The same was done in terms of production factor accounts and households, where all accounts except for the NCP labour factors and NC households were aggregated. This aggregated SAM version used to calculate the economic multipliers consist in total of 35 accounts (i.e. 7 commodities, 9 production activities, 8 factors of production, 6 household groups, a margin account, a government account, a capital account and a rest-of-the-world account).

7.2.2 Results of the economy-wide models

In the case of the CGE model, a 20% decrease in the world fruit price was simulated (abbreviated as PWEDECR). This shock was simulated to quantify its impacts with specific reference to irrigation agriculture within the NCP. Two alternative employment specifications were also investigated, i.e. one a full employment and the other where unemployment sceranios of the unskilled labour categories was allowed.

A critical and central assumption that is made, on macro economic level, is that all arable crops grown in the NCP is irrigated, i.e. due to the relative low rainfall, rain-fed arable crop production is virtually impossible and therefore negligible small in the NCP. It is however important to remember that the SAM used in this analysis is a National SAM for South Africa, with disaggregated detail for agricultural activities, specifically within the NCP. Having said that, cognisance should be taken that if a price or tariff (exogenous world price) of a commodity is "shocked", it reflects a national change, i.e. the price or tariff of the commodity is changed nation-wide. In order to quantify the impact of the shocks on the economy of the NCP, selected NCP variables are then analysed. This was then treated as a top-down linkage approach to the micro economic (farm and regional) models, in that these results are then changed/simulated in the micro economic models.

Some of the main results from the 20% decrease in the world price of fruits, include:

- National GDP reduces by 0.027%;
- NC1 (Gordonia, Namakwaland and Kenhardt) is the most affected, with a decline in regional GDP of 15.7% followed by, Kimberley (NC8) with a negative impact of 0.7%;
- The intermediate input prices for the majority of the activities accounted for in the model experience a decline, ranging between -0.27% and -0.03%. The following NCP agricultural activities; NC1, NC4, NC6, NC7 and NC8, all experience a decline in their respective output prices, ranging from a low of -0.1% for both NC6 and NC7 to a maximum decline of -1.5% for NC1.
- The largest decline in activity producer prices (-1.5%) for NC1 corresponds to the fact that fruit is the most dominant commodity (64% of the total output quantity) produced within NC1. Similar, NC8, which has the second highest fruit output share (13.6%) recorded the second largest decline in activity producer prices with the NCP. In terms of

the other provinces, the Western Cape (WC), Eastern Cape (EC), Limpopo (LP) as well as Mpumalanga (MP) also show a decrease of 0.7%, 7.3%, 10.5% and 12.6% respectively in their activity output levels.

- The largest negative impact felt among the eight NCP activities are in NC1 with an estimated R 199 million decline in total value added, followed by NC8 with nearly R 2 million. The value added in other provinces like: WC, EC, LP as well as MP also decrease with between R 67 million for the WC and R 488 million for MP. The relative large change in total value added experienced by NC1, LP and MP are all resulting from the relative large share (>10%) in the quantity of fruit produced within the specific activity.
- The domestic supply prices (of commodities produced and sold domestically) of potatoes and vegetables (3%), other field crops (0.94%), summer cereals (0.29%) as well as other horticulture (0.15%) increase for both the employment scenarios, whereas the corresponding prices of fruit (-8.3%) and winter cereals (-1.9%) are negatively affected as a result of the decrease in the world fruit price.
- The quantity of fruit exports decrease with 37% on average for both employment scenarios.
- On the import side, the simulation shows a 15% decrease in the quantity of fruit imports, with an insignificant difference between the two employment scenarios. The decrease in fruit imports are probably substituted for by locally produced fruit not exported any as a result of the lower world fruit price. The imports of summer cereals increase with 0.2%, followed by other flied crops (0.6%) and potatoes and vegetable (5.5%) increase as a result of the simulation under investigation whereas winter cereals and other horticultural imports also decline similar to the fruit imports.
- In terms of the semi- and unskilled labour categories employed in the NCP, African labour increases by 0.4%, whereas Coloured and White labour decrease by 1.1% and 2.2% respectively. Overall for all provinces, the largest decline experienced is semi- and unskilled white labour residing in the NCP with -2.2%.
- The rate of return to land as primary production factor increases marginally, with 0.2%, on average for the country as a whole following the 20% decrease in the world fruit price. More specifically, the return to land in the NCP increases on average with 2.7%, however, underlying this positive impact the major fruit producing regions in the NCP (NC1 and NC8) are affected negatively.
- Resulting from the world fruit price shock, 18% (7 out of 39) of the national HH categories increased their consumption expenditure with an average increase of 0.18% for both the full employment and unemployment labour scenarios. The average decrease in HH consumption expenditure for the remaining 32 HH categories are 0.3% for the full employment and 0.42% for the unemployment labour scenario.
- The Equivalent Variation (EV), a welfare measure indicating the money equivalent the HH is better (worse) off as a result of the shock/simulation. HH residing in the NCP are

R 31 million worse of as a result of the fruit price shock, which is the net result of a R 3.6 million increase in the total welfare of NC African HH's and the R 34.6 million decline in the welfare of the NC Coloured and White HH's.

- In the case of the full employment scenario (PWDECR), the larger national government deficit or (dis-) savings comes as a result of the larger decrease in government income (-0.13%) compared to the decrease in government expenditure (-0.08%).
- In the case of the unemployment scenario (PWEDECUE), government income nationally decrease even further to (-0.2%) and with government expenditure being equal for both employment scenarios (-0.08%), government deficit increase with 1.12% compared to the base (initial equilibrium).

The economic multipliers are calculated using the same SAM (but only slightly more aggregated version) as macro economic database as in the CGE case described above. Three sets, i.e. labour, production and value added multipliers are calculated for all activities in the economy as group in the SAM. The direct, indirect and induced multipliers, which sums to a total multipliers are all reported in Chapter 6. These multipliers are then used in the form of a bottom-up approach to simulate/quantify the macro economic impacts of the micro (farm and regional) level simulations. Four micro economic (regional model) scenarios are selected, all characterised by a 20% reduction in the price (producer or farm-gate price) of table grapes, whereas they differ in terms of the variation allowed in area produced, as well as the allowance of water trade. Scenario 2 (as named in Louw *et al.,* 2007) is the same as the base with a 20% deviation allowed in long-term crop area, whereas scenario 5 represents a 60% permitted deviation in the long-term crop area. Scenarios 9 and 12 are respectively the same as scenarios 2 and 5 above, only with water trade allowed. The annual and long term (20 year) objective function value of the regional level (micro economic) model is used as proxy to illustrate the macro economic impacts. Some of the main multiplier results include:

Labour impacts:

- According to the annual R 1 264 million output from irrigation agriculture in the NCP (from the micro-economic model), 17 828 full-time jobs (direct) are created within irrigation agriculture within the NCP, which leads to an additional 3 580 full-time job opportunities in the industries supplying production inputs to irrigation (i.e. indirect effect). In terms of the induced effects, a further 12 547 full-time jobs are created as a result of the demand for consumables created from the wages and salaries paid out in the direct and indirect sectors. The total employment effect therefore adds up to 33 955 full-time jobs created from the R 1 264 million worth of output in irrigated agriculture in the NCP.
- Scenario 2 (see Louw *et al.,* 2007) results in a 25% or R 316 million decrease in the objective value or output from regional irrigation agriculture, which in turn results in a total lost of 8 505 full-time jobs, consisting of 4 465 farm-level (direct) jobs, 897 input-supplying or industry-level (indirect) jobs, and 3 143 induced job opportunities.

Production impacts:

- The R 1 264 million output from irrigation agriculture in the NCP results in additional indirect production to the value of R 778 million and an induced production demand of R 1 827 million, aggregating to a total production (output) of R3 869 million.
- In the case of scenario 2, total production decreases by R 969 million as a result of the 20% decrease in the farm-gate price of table grapes.
- When water trade is allowed the impact is less severe, with an observed decline in total economic output of R 793 in the case of scenario 9. An increase in total production (R 147 million) can be expected when structural adjustments are allowed in long-term irrigated agricultural crops in the case of scenario 5, whereas the same scenario – together with the possibility of water trade – results in an R 321 million increase in total economic output.

Value added impacts:

- The R1 264 million increase in irrigated agricultural output results in R 796 million worth of direct value added, R 298 million worth of indirect value added and R 786 million worth of induced value added, indicating that each R 1 worth of production leads to an additional R 1.88 worth of value added.
- The ability of farmers to trade irrigation water results nearly in an R 100 million improvement in agricultural and related value added compared to the scenarios where trade were not allowed. However, when the model allows structural adjustments in terms of crop areas, the impact is significantly greater with an improvement of over R 540 million in total value added in both cases.

7.3 CONCLUSIONS

The macro economic scenario analysed, illustrate that exogenous macro economic factors (risks or shocks) can have a tremendous impact of varying degrees on the economy but more specifically the agricultural economy of a region or province like the NC. The CGE model reports the “new” equilibrium situation where the economy returns to after a shock have been imposed on the economy as a whole. Such a new equilibrium provides valuable insights of the economy-wide effects or impacts on: different sectors of the economy, commodities produced, factors of production, socio or households level as well as on government that are likely to result from a change or shock.

Given that the simulated shock is specific to the fruit industry, i.e. 20% decrease in world price of fruits, the different regions in the NCP as well as the other provinces are affected to different degrees. As the local fruit prices, linked to the international prices, decrease, the local value of fruit output obviously decreases, leading to a series of effects on related economic sectors, i.e. the factors of production involved and likewise also the wealth of society directly and indirectly involved in the fruit industry. These simulated result on different variables, i.e. local prices of inputs and outputs, volumes of production as well as demand can then be used in a stand alone linkage (i.e. top down or macro-to-micro) to simulate farm or regional level impacts by means of the DLP models developed by Louw *et al. (2007)*.

As explained earlier, the world fruit price simulation is one of a series of simulations that can be analysed within the CGE framework, and therefore demonstrates the functioning of the model. Other possible simulations include: tariff or tax rate simulations for example or any other shocks imposed on exogenous variables in the CGE model. In addition to these simulations, alternative macro economic closure can also be chosen to analyse the impact thereof, including the external balance, the savings-investment balance, the government balance as well as the factor market balance.

The bottom up (micro-to-macro) linkage between the regional and macro economic models is done by means of the economic multipliers calculated. This was done specifically to quantify the economy-wide impacts of a certain changes in the total fruit output for example in the NCP, i.e. the results from the regional model. The three sets of multipliers; labour, production and value added multipliers were used to calculate the macro economic impact (economy wide multiplier effects) of the simulated results from the regional model. The direct, indirect and induced effects of the so-called backward economic effects together provide an indication of the total economic impact of a simulated shock.

Based on the macro economic results of the CGE model and economic multipliers it can be concluded that irrigation agriculture in the NCP, indeed has a major impact on the provincial and therefore also national economy. In a province like the NC, where irrigation plays such an important role, it is critical that this resource is well reserved and managed. Effective water resource management calls for an integrated management approach, and due to the highly political nature of water, this management process should ideally be distant from political pressures. The institutional context within which water is managed is critical and in this regard, the balance of power between central government, municipalities and/or the private stakeholders will ultimately influence the final outcome.

With water use in South Africa approaching its full potential, water demand as well as supply management should continuously be improved and further developed. Compared to international standards or benchmarks, South Africa is relatively under-developed in terms of water supply-side management. Innovative technological development combined with cutting edge research in this field, is the only way in which water will ultimately advance effective use. On the supply side, water infrastructure developments require significant amounts of capital investments in public goods. The user rights therefore pose huge challenges to authorities of the day, especially in South Africa with its legacy of the past, to ensure the equal though effective utilization of the resource available in a sustainable manner. The role of PPP should again not be underestimated in this regard, specifically because of the huge investment cost that can not be financed by the state alone, as well as to ensure commitment from all different levels.

Further improvement in the enforceability of volumetric water allocation, are likely to improve the effectiveness of water use in all sectors, especially in irrigation agriculture, where water supply are continuously under pressure. Stricter enforcement and incentives for "water savers" should therefore be implemented. Leasing arrangements of water licences based on equity principals, if done correctly (wisely) in partnership (or in the form of a mentorship programme/agreement) with commercial farmers already established in existing agricultural value chains, may help to excel the process of getting these subsistence farmers into the main stream agriculture. In stead of high water tariffs that increases the transaction and production cost of irrigation farmers, effective water markets, based on pure economic principals, will in the future further improve and enhance the effectiveness of water resource use.

At farm level (demand side), irrigators have the responsibility to ensure the effective utilization of irrigation water, through proper management, accountability and also investment in proper infrastructure in terms of the latest technological developments. A code of conduct for irrigators, which can be self administrated and which is developed in close collaboration between all role players involved, including the irrigation farmers, will assist in ensuring the effective use of this resource. The advantage of such an inclusive (i.e. bottom-up) management approach lies in the very consultative nature of this process and farmers can hereby ensure that their needs and therefore inputs have beneficial outcomes. This approach is also consultative in nature, works with the ordinary grassroots level water users and are therefore robust organizations that generates benefits to their members instead of the typically weak top-down approach suffering from a high risk of failure.

The more active participation of industry and organized agriculture and specifically in terms of the development of the code of conduct mentioned above as well as the creation of PPP's will also improve water service delivery, and thereby also the relative effectiveness of irrigation water use. This is further also important due to the fact of high investments costs in the water sector, requiring innovative financing mechanisms. Such mechanisms can range from government institutions need to promote private investments, fostering PPP, implementing full cost recovery pricing systems, facilitate access to international funds for developing countries and access to micro credit which can encourage structured water service charges that can be used to increase the effectiveness of irrigation water use. DWAF can further also put incentives in terms of charges in place for irrigators to switch to more effective irrigation technologies or higher value (i.e. virtual water content) crops.

The role of government should therefore ideally be limited to the facilitation of the integrated water resource management process. Currently, the degree of private involvement in South Africa is limited to outsourced public administration with retained ownership of water infrastructure by the sate. The next step will be that ownership, administration and management becomes entirely the responsibility of the private sector, i.e. limited state intervention and thereby also minimised political influence.

It was also shown that by knowing the virtual water content of products, consumers become aware of the volume of water needed to produce the various goods, thus providing an idea of which goods impact most on the water system and where water savings best could be made. Creating common public awareness among consumers of their individual water footprint can therefore stimulate a more careful use of water. The reduction of virtual water in consumers' diets may contribute significantly to water savings and therefore effective use of scares irrigation water.

The closer involvement and commitment by government to reduce the transaction cost, specifically with regard to water trade issues, are likely to encourage a more active and efficient market for irrigation water. This in turn is likely to have a positive impact on trade and thereby also the macro economy of the NCP in general. A clear distinction with different sets of rules and regulations for long and short run trade will further also enhance the trade effectiveness. This is especially true in the case of short term trade or water right leasing, where mentorship and partnerships play a crucial role. It is therefore clear that in an integrated water management system, the need for high water tariffs are reduced and much more effort and attention can therefore be afforded to better marketing information, etc.

Despite the fact that there's enough water in South Africa, i.e. the chances of an absolute water shortage are low (Backeberg, 2005), the efficient allocation thereof remain a critical and top priority. Nationally, as is the case in many other international situations, agriculture uses the "lions share" (i.e. 62% in South Africa) of local water requirements (see DWAF, 2002; Backeberg, 2005 and Roe *et al.,* 2005). However, this demand vary significantly between regions, in South Africa DWAF (2002) for example shows that it varies from 9.5% in the Upper Vaal compared to the 93.5% in the Lower Orange, with the latter forming part of the study area under investigation. It is therefore of utmost importance, especially within a situation of growing water demand, that the efficient use of all water uses, but especially irrigation agriculture in such regions are ensured by all role-players involved in an integrated approach. Innovative technology development should therefore also focus on the development of alternative, preferable high value crops and irrigation techniques that can increase the effectiveness of irrigation water use.

Various authors in the past (including: Kirsten and Van Zyl, 1990b; WRC, 1996; Mullins, 2002; and Backeberg, 2005 for example) recognized the contribution irrigation agriculture makes to the broader economy, and hence to factors like: income generation, food security and poverty alleviation to mention a few. This study adds to this group of literature, and contributes in the sense that it specifically focus on quantifying the macro economic impact of selected shocks/changes on the economy of the NCP where irrigation agriculture makes a major contribution.

The current process of authorizing water use in terms of the NWA, which started with the registration of all water users, will be followed by compulsory licensing in the near future. In the NWRS, it states specifically that the responsible authority (i.e. DWAF) must identify users especially from marginalized or disadvantages groups, to ensure that the available water is allocated fairly (DWAF, 2002 and Backeberg, 2005). However, as stated above, the other two major objectives are “sustainability” as well as "efficient and effective water use” that will ensure optimum social and economic benefit to all. The only way in which this can happen is with an integrated approach where all role-players involved takes active responsibility in ensuring this, and thereby reducing the risk of losing international market shares. As mentioned above the current South African water law is considered among the best written water laws internationally. The challenges however remain with the successful implementation and regulation thereof.

From the simulated economy-wide results it is clear that any shock affecting irrigation agriculture to some extend have tremendous repercussions on employment, HH and government income, consumption expenditure and welfare of HH’s, especially in a province like the NC. It is therefore the responsibility of the national and provincial government to ensure that the necessary support systems in terms of efficient extension, operating capital as well as technical and marketing expertise are available to the recipients or beneficiaries of these equity schemes.

In particular, governing institutions will need to ensure that both the urban and rural population have access to safe drinking water and sanitation services, bearing in mind environmental constraints, but not jeopardising economic development. This requires institutional and technological innovation, and calls for: - the strengthening of existing institutions mandated with water management tasks; - the adoption of a two-pronged strategies, dealing on the one hand with water supply and, on the other hand, managing water demand; - urgently reforming and modernising the agricultural sector, favouring less water intensive crops and more efficient irrigation technologies; - improving water quality and tackling health related issues; - building capacity to deal with crisis situations, such as floods and droughts, as well as implementing an early warning signal to limit the damages; and - fostering international cooperation among countries sharing water resources.

7.4 RECOMMENDATIONS

The final sub-objective is to make recommendations on the institutional responses required to mitigate the effect of external shocks and thereby increase the effectiveness of water management for regions where irrigation agriculture makes a major contribution to the economy in regions like the NCP. As showed in Chapter 3, where a synopsis of the current SA water law was given, most of the “ideal” governance and management frameworks (according to international standards, as listed in Chapter 2) are already in place. The major current challenges with such a relative “new legislation” rest with the implementation and in some cases the interpretation of these regulations. This section therefore doesn’t call for major reformulations of current water policies of any kind, but rather urges for guidance and strategies with the rapid implementation thereof. It therefore strives to suggest possible frameworks and responses on institutional level that can ease the smooth and effective implementation thereof.

In the next sub-section recommendations are made on implementation issues of the current water law, in order to improve or ensure the effective management of this vital important resource. This is followed with recommendations for future research on selected topics.

7.4.1 Institutional response required

In terms of the institutional setting, it was explained in Chapter 2 that clear roles and responsibilities must be assigned to the designated authorities. Various authors (including: Sgobbi and Fraviga, 2006; Gleick, 2000 as well as Borzel *et al.,* 2005) recommends one single institution to be responsible for the strategic planning as well as development and management of water resource strategies. The South African DWAF is exactly responsible for this, however, Sgobbi and Fraviga (2006) further specifically recommends this body to be independent, but reporting to the national government, in order to ensure its neutrality with respect to the interests of different users and needs. This is specifically important due to the highly political nature of a strategic natural resource like water, and this despite being a major challenge, can be in the form of an agency, managing the national water resources therefore on behalf of government. The DWAF, together with the implementation bodies created, should therefore strife to engage in managing water distant from political pressures to ensure effective management and utilization.

DWAF (2002) explains that “for many years the tendency has been to resort to constructing additional infrastructure where the demand for water has exceeded the supply”. With the current situation in South Africa where water use approaches its full potential, the cost of resource development increases and the environmental impacts are becoming more pronounced. It is estimated for example that four out of the ten water management areas currently in deficit would change to a surplus with a 10% saving in current water use requirements (DWAF, 2002). It is furthermore clear from the NWRS (DWAF, 2002) that the management of **water demand** (as a reconciliation intervention) in South Africa is relatively under-developed compared with supply-side management, despite numerous existing world-class examples of increased water use efficiency in some industrial and agricultural areas that assist with setting benchmarks and standards. This however will require combined innovative technological development that will only be possible via cutting edge research in this field, which will ultimately advance effective water use. Water allocation in SA is based on a volumetric system, however, due to different ways of measuring water flow in different sectors and regions, the enforceability thereof are highly questionable. This inability to properly measure water flow, may lead to the over-use (and hence highly likely inefficient use) of water. Further improvement in the enforceability of volumetric allocation, are likely to improve the effectiveness of water use in all sectors, especially in irrigation agriculture, where water supply are continuously under pressure. Stricter enforcement and incentives for “water savers” should therefore be implemented.

Another important reconciliation intervention described in the NWRS includes the re-allocation of water. One of the main objectives of the water law is that water should ideally be applied to the best advantage and thereby achieves the greatest overall benefit for the country from a social, economic and environmental perspective. In order to achieve this, re-allocation of water between user sectors is suggested as an obvious and powerful option (DWAF, 2002). However, it can be envisaged that this may cause unnecessary tension between the different users of water if done injudiciously. DWAF (2002) propose and describe the envisaged process of **compulsory licensing**, supported by water demand management and the trading of water use authorisations as a main enabling mechanism. If done wisely (i.e. on a well-informed scientific basis) re-allocation can improve the overall effectiveness of water utilization. However, the mere fact that compulsory licensing are scheduled to take place in some cases within the next 15 years, shows that the way in which the licensing procedure should take place, are not yet fully understood. This again calls for thorough and in-depth multi-disciplinary research in this field to generate innovative mechanisms that will assist with the licensing procedure. Particular in this field, the economy-wide modelling framework developed in this part of the study can assist to a great extend with “what if” policy or implementation strategies.

In order to reach the “best possible use of water”, the NWP requires the compilation of a legal framework, that specifically balance the social, economic and environmental objectives in order to achieve equity, efficiency and sustainability. Water allocation through pricing and markets are proposed, however, different control measures are proposed to ensure the practical implementation as well as protection of the interest of the poor (Backeberg, 2005). In this regard, Backeberg (2005) further explain that the trade in water licences can be a way to achieve equity of access or to increase efficiency of water use by moving water from lower-value to higher-value uses. This will however be permitted under certain conditions, i.e. preventing subsistence farmers from selling water rights for short term gain but rather promote leasing of water rights that may enable these farmers to raise cash for development. This type of leasing arrangements, if done correctly in partnership (or in the form of a mentorship programme/agreement) with commercial farmers already established in existing agricultural value chains, may help to excel the process of getting these subsistence farmers into the main stream agriculture. The social responsibility of individuals involved will play a critical role, which can be assisted by trustworthy and efficient public entities. In this way, PPP should also be nurtured, encouraged and facilitated by the institutions involved. It is furthermore important for the commercial agricultural sector to realise and therefore reap the potential benefits of such partnerships. The public sector and subsistence farmers should however realise that such a partnership must be based on business related principles (win-win situation) in order to guarantee success. Critical success factors for PPP's include that such a project must be value for money, affordable in net present value terms and should be based on a risk sharing principle among all partners.

In conjunction to the trade of water licences in the previous paragraph, the concept of Virtual Water (VW - explained in Chapter 2) can be used to steer not only irrigation water use to its best potential use for society as a whole. Research in this field of VW, where a country with scares water resources imports products which require large quantities of water in its production process, if linked into the system of already existing DSSs, can provide valuable information to irrigators in terms of new developments or re-establishment of current crops or cultivars. Given this close link of optimal use with the theory of international trade and therefore VW, it is important for government to assure the effective utilization of local water resources by making it an integral part of the national water, food as well as environmental policies. The VW contained in products should therefore be included in decisions based on comparative and competitive advantage studies done for trade related policy decisions. There is thus also a close link and therefore also responsibility between water policies and other environmental policy issues. Allan (2003) states that "virtual water trade is so successful because it is invisible and is applied beyond the general political debate". However, invisibility may lead to postponement of necessary reforms by politicians as imports can be regarded as 'secret reserves' that might bail out in the short run.

Effective technological innovations and developments can only become a reality in a "research orientated" milieu. Numerous examples exits internationally (of which some were described earlier in this document) where research have led to innovative developments in terms of more effective water supply and demand. For this to become a reality, commitment to more effective water use from all role players involved are required. It is however not the role of government in society to conduct all research, but rather to provide an enabling and supportive environment for research institutions.

State of the art infrastructure, both on the supply and demand side, is crucial to ensure the effective utilization of water. This is however a challenge especially when it comes to irrigation water. On the supply side, the infrastructure developments require significant amounts of capital investments in public goods. The user rights therefore pose huge challenges to authorities of the day, especially in South Africa with it legacy of the past, to ensure the equal though effective utilization of the resource available in a sustainable manner. The role of PPP should again however not be underestimated in this regard, specifically because of the huge investment cost that can not be financed by the state alone, as well as to ensure commitment from all different levels.

As explained by Sgobbi and Fraviga (2006), "the success of IWRM depends to a large extend on the institutional context in which the process takes place, both at the national and international level". The balance of power between central government, municipalities and/or the private stakeholders influences the final outcome. It should be clearly understood that both ethical and political considerations play a crucial role in shaping governments approach to water resource management. The responses, by different levels of institutions are discussed in the following four sub-sections. Even though discussed separately, these response, actions and responsibilities are closely interlinked and (should) come to pass in a coherent manner as proposed by the IWRM concept defined and proposed.

7.4.1.1 Farm level response

As explained above, effective use of irrigation water is just as much a demand side function as it is a supply side one. Irrigators on the demand side, have the responsibility on farm level to ensure the effective utilization of irrigation water. This requires proper management, accountability and also investment in proper infrastructure in terms of the latest technological developments. Both financial implications thereof (these technologies) at farm level as well as ethics will influence the extent to which irrigation water is utilized.

A code of conduct for irrigators, developed in close collaboration between all role players involved, including the irrigation farmers, will assist in ensuring the effective use of this resource. Aspects that should be covered in such a code should include basic practical guidelines, like: when how, where and how much to irrigate, as well as aspect on technological improvements and innovations that can be used, etc. Such a code of conduct should obviously not be set in concrete, but rather be updated on a regular basis, which can also serve the purpose to communicate and explain new developments and technologies to the irrigators.

From the discussion above on the integrated approach to irrigation water management, the active participation of irrigators (farmers) themselves are crucial for success. The advantage of such an inclusive (i.e. bottom-up) management approach lies in the very consultative nature of this process and farmers can hereby ensure that their needs and therefore inputs have beneficial outcomes.

7.4.1.2 Industry or organized agriculture response

Many direct and indirect marketing and operational functions that cannot be managed efficiently by individuals should be managed at a higher level by industry organisations (such as the Deciduous Fruit Producers Trust and Fruit South Africa for example) or organised agriculture (Agri- Northern Cape and Agri-SA). These functions should also constantly be reviewed and programmes and actions should be developed to address them, including issues such as:

- Industry information DSS, including information such as key industry statistics, orchard/vine/ census for production regions, crop estimates, fruit flow information (intakes and shipments), market destinations, national/international industry overviews, production cost, supply chain cost benchmarks, and strategic issues for specific industries, etc.
- Support government with industry information to negotiate international trade issues like market access and other trade agreements.
- Facilitate research on market access compliance issues.
- Support service and input providers with annual and long-term crop estimates to enable more efficient logistical planning.
- Facilitate supply chain cost studies to increase the efficiency of the marketing chain.
- Support communication forums between marketing organisations and producers.
- Negotiate with government to reduce the cost of doing business in the NCP.
- Develop industry strategies to support negotiated agricultural policies and initiatives such as the Strategic Plan for Agriculture and ASGISA.
- Provide inputs on various forums where other agricultural related policies are discussed and negotiated.
- Facilitate special export programmes.
- Development of local and export quality standards.
- Development of codes of conduct for major stakeholders in the supply chain including producers, exporters, fruit handlers (cold rooms, pack houses, transporters, harbour personnel, marketers, retailers, etc.)
- Support the National Agricultural Marketing Council (NAMC) with market-related research.
- Represent SA producers at international marketing / commodity forums and conferences.
- Facilitate cooperation between the local industries and international industry experts.
- Support research initiatives from both the private and public sector and assist with the dissemination and capacity transfer of research results and new technological developments.

There are probably many other support services that industry can provide. The most important, however, is to supply farmers with independent, objective and timely information and to negotiate with government to introduce agricultural policies to reduce the cost of doing business and to gain and maintain access to international markets.

Industry or organized agriculture therefore forms a crucial link between farmers (irrigators) or producers and the public sector. Organized agriculture has a crucial role to fulfil both in terms of the development of the code of conduct mentioned above as well as the creation of PPP's in an effort to improve water service delivery.
A more active participation of organized agriculture in the governance of irrigation is a sound institutional arrangement that has proved successful in many countries (see Herrera et al*.,* 2005), provided some conditions are met. These conditions includes firstly the

establishment of better backward linkages between farmer's and input supply systems (financing included) and secondly better forward-linkages with output marketing systems. Herrera *et al.* (2005) further also explain that these linkages are typically outside the boundaries of irrigation institutions, which implies that a broader view of institutional change is therefore necessary.

7.4.1.3 National and provincial government response

In general, the role of government is to provide a safe, friendly and enabling environment in which the private sector can grow the economy. In this regard, the provincial government of the NC can play an important role in terms of:

- Support research initiatives (such as this study) to reduce risk for farmers.
- Invest in an efficient provincial Department of Agriculture to conduct and facilitate research and extension services that will reduce production and marketing risk and thereby also improve the efficiency of water use in general and irrigation water specifically.
- Invest in an efficient Department of Economic Affairs to build relationships with other countries and to promote provincial specific crops (such as the Green Kalahari initiative).
- Investment in and maintenance of effective and suitable infrastructure (transport, communication, water works etc.).
- Negotiate with national government on provincial specific issues that will reduce the risk and improve the efficiency of farmers (e.g. water quality and water allocation or trade issues).
- Assist local industries to reach their goals, the provincial Minister of Agriculture should develop an agricultural policy that is comprehensive, integrated, and ensures that producers have the tools to address issues, be competitive, and capture the opportunities these challenges present in the areas of science, food safety, and environmental stewardship.
- Provincial government should create an environment where producers actively manage their business risks using an appropriate combination of private sector and public sector risk management tools, such as the analytical tools developed in this study.

Similar to provincial government, national government should also assist in the creation of an enabling environment that reduces business risks for private entrepreneurs. All major policies that impact on the agricultural sector and could directly or indirectly increasing marketing risks and effective water management are determined by national government. The role of national government is clear:

- Create and maintain the capacity to negotiate multi-lateral and bi-lateral trade agreements with foreign governments.
- Give guidance and support though the national Department of Agriculture of the requirements to gain and maintain market access.

- Protect local industries from unfair trade through an efficient customs service and inspection of the country of origin in the case of fruit to ensure that all phytosanitary measures are in place.
- Develop agricultural policies that are “agriculture-friendly” and structured in such a way as to minimise the cost to the industry. Government should always consider the economy-wide impact of agriculture in any policy decisions that increase the cost of doing business; high costs normally increase market risks.
- Strong support to the NAMC to address market-related threats and opportunities.
- An open door policy for industries to discuss issues that threaten to deprive industries of market access (for example, “food miles” or “carbon foot prints”).
- Infrastructure development to create efficient value chains.
- Financial support to develop efficient market information systems. In this regard, government could play an important role in negotiating information exchange agreements between South Africa and other countries.
- Financial support thought the Department of Trade and Industry (DTI) to support industries to promote South African products overseas.
- The collection and provision of relevant and accurate information, including weather and disasters, market and other macro economic related information.
- Research support and facilitation on various disciplines.
- Effective implementation of water policies and regulations.
- Development and maintenance of supporting infrastructure, including logistics which are probably one of the largest current challenges.
- Ensure the successful establishment and sustainable future production practices by small-scale or developing farmers.

Due to the highly political nature of water and even more specifically irrigation water, government should ultimately allow the independent management and allocation of water. The degree of private sector involvement in the delivery of water service can range from 1) direct public administration to 2) infrastructure retained ownership by the state and outsourced service deliver to a model, where 3) ownership, administration and management are entirely the responsibility of the private sector.

In this regard, Magingxa (2006) explain that the National Water Act (NWA), (Act 36 of 1998); provides for the creation of new Water Resource Management (WRM) institutions called Catchment Management Agencies (CMA’s) and Water Users Associations (WUA’s). Whilst the government will remain the custodian of the country’s water resources, a lot of regulatory functions have been transferred to these institutions. Water service delivery in SA is therefore moving to the second model listed above, i.e. where some service delivery are in the process of being outsourced to the “private sector” in the form of the WUA’s created. However, only 1 (Orange-Vaal) of the 25 irrigation boards in the NCP has a fully operational WUA whereas all three state water schemes (Kakemas, Boegoeberg and Vaalharts) are also fully operational as WUA's (Snyders, 2007). The dissolution of Irrigation Boards and concomitant formation of WUA's means that small farmers have to participate in the same institutions with large-scale commercial farmers. There is thus clearly a lot of room for improvement in this regard that will certainly increase the effectiveness of service delivery and therefore also supply and demand of irrigation water. The code of conduct for irrigators called for above can also be used to outline the mandate of DWAF and thereby distance itself from highly political pressures. The role of the public sector therefore reduces to that of a watchdog, ensuring that increased efficiency in water use and service delivery is not to the determent of equity and social balance.

Various authors in the international literature on water management (including: Ostrom, 1992; Merrey, 1996; Vermillion, 1999 as in Herrera *et al.,* 2005) suggest that water users must play a larger role in their governance, financing, and management in order for irrigation systems to be productive and sustainable, i.e. a bottom-up management approach. According to Herrera *et al.* (2005) the advantages of a bottom-up approach for organizing irrigation management is that it is consultative in nature, works with the ordinary grassroots level water users and are therefore robust organizations that generates benefits to their members instead of the typically weak top-down approach suffering from a high risk of failure. The challenge however lies in the sustainability of such an arrangement, primarily due to the problem of accountability.

Investments in the water sector require innovative financing mechanisms (Sgobbi and Fraviga, 2006). Such mechanisms can range from government institutions need to promote private investments, fostering PPP, implementing full cost recovery pricing systems, facilitate access to international funds for developing countries and access to micro credit which can encourage structured water service charges that can be used to increase the effectiveness of irrigation water use. Ultimately such charges should be of a full-cost recovery basis for all water users. However, the public nature of irrigation water infrastructure (dams, channels, etc) often complicates such charges which are often high and therefore subsidized. DWAF can further also put incentives in terms of charges in place for irrigators to switch to more effective irrigation technologies or higher value (i.e. virtual water content) crops.

The World Water Council (2004) explains that the "virtual water content of a product tells something about the environmental impact of consuming this product". Thereby, knowing the virtual water content of products creates awareness of the water volumes needed to produce the various goods, thus providing an idea of which goods impact most on the water system and where water savings best could be made. Hoekstra and Hung (2002) explain that the sum of national water use and net virtual water import is defined as the 'water footprint' of a country, which can act as strong tool to show people their impact on the natural resources. Creating common public awareness among consumers of their individual water footprint can therefore stimulate a more careful use of water. The reduction of virtual water in consumers' diets may contribute significantly to water savings and therefore effective use of scares irrigation water. Government can therefore support research on this issue of VW, and further also run public awareness campaigns of water footprints in order to promote the effective use of this resource. According to the World Water Council (2004) the implications of changing diets on water resources have to be addressed through education. In this regard trading and manufacturing companies could help to enhance awareness by publicising the virtual water content and food miles for example of their products together with the nutritional information.

The macro economic impacts and multiplier effect of agriculture (including irrigated agriculture specifically) was quantified in Chapters 5 and 6 of this report. It was shown that agriculture is one of the main pillars of the economy in the NCP. Redistributing natural resources is therefore not only important from a political point of view but also from an economic point of view. In terms of these equity considerations, it is important for government to realize that access to irrigation water and land by itself doesn't ensure effective use and production as irrigation agriculture in the modern day era is a highly scientific and competitive production process. From the simulated economy-wide results it is clear that any shock affecting irrigation agriculture to some extend have tremendous repercussions on employment, HH and government income, consumption expenditure and welfare of HH's, especially in a province like the NC. It is therefore the responsibility of the national and provincial government to ensure that the necessary support systems in terms of efficient extension, operating capital as well as technical and marketing expertise are available to the recipients or beneficiaries of these equity schemes. This will therefore require the full spread of services, since the support required by individual farmers vary significantly. Only if these proper support systems are in place and functioning well, can sustainable efficient and effective water use be expected form these newcomers. In order to be successful with all this, creating an enabling business environment where transaction costs can be minimized will assist PPP's to be successful. Government can hereby also improve the efficiency of service delivery by attracting private investors, and thereby also ensure technological improvements as well as better managerial capacity.

With such an integrated management approach, it is important for government to assist all farmers (commercial and emerging) in planning future production to ensure that the necessary level of diversification among products/commodities produced is maintained. Often it is seen that market signals, i.e. high prices steer too many farmers simultaneously in the same direction. This then often lead to an over-investment in production capacity of single commodities like in the case of Table Grapes along the banks of the Orange River. As soon as these investments are fully productive and operational, commodity prices decrease due to a general over supply in the market (especially in a niche markets like the NC table grape industry with its early seasonal advantage). This then results in significant losses that are realized, which in turn have severe impacts on the larger macro economy of the province in terms production, employment, wealth and foreign income earned. The spill over effects of such a shock or change was shown with the results of the CGE model in Chapter 5 as well as to some extend by well as the multiplier analysis in Chapter 6. It is therefore of crucial importance for government to assist and be proactive in such a way that economic growth can prosper in the rural economies by supporting the primary industries such as agriculture.

7.4.3 Recommendations on future research

Further research should be carried out on the natural, social, economic, environmental and political implications of using virtual water trade as a strategic instrument in water policy. As mentioned by the World Water Council (2004), "there is a real need for more in depth research to work on the potential of virtual water trade to relieve pressure on the globe's water resources and thereby also to achieve food security in the world's water scarce regions". The concept of virtual water will be helpful in policy making, however the concept itself needs to be further clarified and a clearer and more explicit distinction with common food trade should also be made.

Government should support research on VW, and further also run public awareness campaigns of water footprints in order to promote the effective use of this resource. According to the World Water Council (2004) the implications of changing diets on water resources have to be addressed through education. In this regard trading and manufacturing companies could help to enhance awareness by publicising the virtual water content and food miles for example of their products together with the nutritional information.

The models developed in both parts of this study contribute to the larger set of tools available in a DSS for agriculture and more specifically irrigation agriculture per se. The scenarios analysed were chosen specifically because it mimics closely what happened in reality in the national and international markets in the recent past. There is however numerous other impacts or scenarios that can be tested or analysed with these models and it is therefore recommended that the human capacity created in this project are transferred and thereby also further developed in a follow-up capacity building project. The application and future use of these models developed therefore strive to assist policy makers, in the form of integrated DSS, in designing an effective IWRM framework in close collaboration with the private (national and international) sector. More specifically in addition, the models developed in this study can potentially contribute significantly in terms of the compilations of business plans for the establishment of future WUA's not only in the NCP but also in the rest of the country.

In terms of the macro economic modelling framework, the inclusion of time, i.e. dynamics into the CGE will further add value to the macro economic results, as structural adjustments over time in the larger economy can thereby also be simulated. A more direct linkage, i.e. embedded micro economic framework inside the macro economic model, may also add value to the current separate micro and macro economic frameworks applied. In this regard, the farm and therefore regional level database will sum to the macro economic (SAM) database. This will however require extensive data collection, not only in the agricultural sector but also in many other economic sectors.

Updating economic models is a very important task in order to realize future benefits of investments made. It is therefore recommended that the models (both micro and macro economic) should be updated at least every four years as more recent data becomes available. This however remains a costly and time consuming process and therefore also calls for the collaboration with other projects of the Department of Agriculture for example, in terms of the PROVIDE project.

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Appendix 4A: Aggregate macro PROVIDE SAM 185
Appendix 4B: Account descriptions used in the adjusted PROVIDE SAM 186
Appendix 4C: GAMS code for CGE model: 191
Appendix 4D: GAMS code for CGE simulation 196

Appendix 4A: Aggregate macro PROVIDE SAM

	C_AGR	C_NAGR	MARGINS	A_AGR	A_NAGR	F1	Land_RRS	Land_NC	Labour_R	Labour_N	HH_RRSA	HH_NC	DIRTAX	GOVT	ENT	KAP	DSTOC	TAX	SUB	ROW	TOT
C_AGR				74944	21826						172239	3600					2902			20677	296187
C_NAGR			205818	53124	934285						386880	9287		162988		140318	4182			235918	2132800
MARGINS	79367	126452																			205818
A_AGR	181139	12135																			193275
A_NAGR	1504	1683019																			1684523
F1				30185	339787															15150	385122
Land_RRSA				3206																	3206
Land_NC				250																	250
Labour_RRSA				32397	393516															2090	428003
Labour_NC				2092	7492															149	9733
HH_RRSA						87264	2982		424050		25806	250		29243	107842					258	677696
HH_NC						2196		232		9430	251	2		618	3165					2	15895
DIRTAX											83775	2576			33094						119445
GOVT											1812	58	119445		9655			116373	-15307	481	232517
ENT						140837	160	13						52971	140030						334011
KAP						119429					6807	122		-20294	40146					1192	147402
DSTOC																7084					7084
TAX	16102	100272																			116373
SUB				-2924	-12383																-15307
ROW	18076	210921				35397	64	5	3953	302	127	1		6990	80					27330	303247
TOT	296187	2132800	205818	193275	1684523	385122	3206	250	428003	9733	677696	15895	119445	232517	334011	147402	7084	116373	-15307	303247	

Source: PROVIDE (2005)

Appendix 4B: Account descriptions used in the adjusted PROVIDE SAM

Name	**Description**
C1a	Summer Cereals
C1b	Winter Cereals
C1c_e	Other Field Crops
C1f	Potatoes and Vegetables
C1g	Wine grapes
C1ijk	Fruit
C1k	Other Horticulture
C1lm	Livestock products
C1nt	Other agriculture
C1o	Poultry
C1pr	Other Animals
C1qs	Forestry and fishing
C2	Coal and lignite products
C3	Gold and uranium ore products
C4a	Crude oil products
C4b	Other mining products
C5	Meat products
C6	Fish products
C7	Fruit and vegetables products
C8	Oils and fats products
C9	Dairy products
C10	Grain mill products
C11	Animal feeds
C12	Bakery products
C13_14	Confectionary products
C15	Other food products
C16	Beverages and tobacco products
C17_25	Textile products
C26_31	Wood paper media products
C32	Petroleum products
Cchem_prods	Other chemical products
C34	Fertilizers
C36	Pesticides
C41_43	Rubber plastic products
C44_48	Non-metallic products
C49_59	Iron and steel products
C60	Agricultural machinery
C61_66	Special purpose machinery
C67_72	Electrical products
C73_74	Audiovisual products
C75_77	Transport products
C78_80	Other manufacturing
C81	Electricity
C82	Water

C83_84	Construction
C85_86	Trade and accommodation
C87	Transport services
C88	Communications
C89_92	Business services
C93_94	Government health social
C95	Other services and activities
C96	Domestic services
M1	Trade margin
M2	Transport margin
AWC	Western Cape Agriculture
ANC1	NC Agric Namakwaland
ANC2	NC Agric Sutherland Karoo
ANC3	NC Agric Victoria West Karoo
ANC4	NC Agric De Aar Karoo
ANC5	NC Agric Kgalagadi
ANC6	NC Agric Carnarvon Karoo
ANC7	NC Agric Frances Baard
ANC8	NC Agric Kimberley
AEC	Eastern Cape Agriculture
AKZ	KwaZulu Natal Agriculture
ALP	Limpopo Agriculture
ANW	North West Agriculture
AFS	Free State Agriculture
AMP	Mpumalanga Agriculture
AGT	Gauteng Agriculture
A1b_c	Forestry fishing
A2	Coal
A3	Gold
A4	Other mining
A5	Meat
A6	Fish
A7	Fruit
A8	Oils
A9	Dairy
A10	Grain mills
A11	Animal feeds
A12	Bakeries
A13_14	Confectionery
A15	Other food
A16	Beverages and tobacco
A17_25	Textiles
A26_31	Wood paper media
A32	Petroleum
Aother_chems	Other Chemicals
A34	Fertilizers
A36	Pesticides
A41_43	Rubber plastic
A44_48	Non-metallic
A49_59	Iron and steel
A60	Agricultural machinery

A61_66	Special purpose machinery
A67_72	Electrical
A73_74	Audiovisual
A75_77	Transport equipment
A78_80	Other manufacturing
A81	Electricity
A82	Water
A83_84	Construction
A85_86	Trade and accommodation
A87	Transport services
A88	Communication
A89_91	Business services
A92_93	Government health social
A94	Activities and services
A95	Domestic services
F1	Gross operating surplus mixed income
FNWC	Western Cape Land
FNNC	Northern Cape Land
FNNW	North West Land
FNFS	Free State Land
FNEC	Eastern Cape Land
FNKZ	KwaZulu-Natal Land
FNMP	Mpumalanga Land
FNLP	Limpopo Land
FNGT	Gauteng Land
FWCaf	Western Cape African
FWCcsk	Western Cape Coloured and Asian Skilled
FWCcusk	Western Cape Coloured and Asian Semi- and unskilled
FWcw	Western Cape White
FECafsk	Eastern Cape African High-skilled and skilled
FECafusk	Eastern Cape African Semi- and unskilled
FECc	Eastern Cape Coloured and Asian
FECw	Eastern Cape White
FNC1	Northern Cape African High-skilled and Skilled
FNC2	Northern Cape African Semi- and Unskilled
FNC3	Northern Cape Coloured and Asian High-skilled and Skilled
FNC4	Northern Cape Coloured and Asian Semi- and Unskilled
FNC5	Northern Cape White High-skilled and Skilled
FNC6	Northern Cape White Semi- and Unskilled
FFSafsk	Free State African High-skilled and Skilled
FFSafusk	Free State African Semi- and unskilled
FFSc	Free State Coloured and Asian
FSw	Free State White
FKZafsk	Kwazulu-Natal African High-skilled and skilled
KFZafusk	Kwazulu-Natal African Semi- and Unskilled
FKZc	Kwazulu-Natal Coloured
FKZas	Kwazulu-Natal Asian
FNWaf	North West African
FNWca	North West Coloured and Asian
FNWw	North West White
FGTafsk	Gauteng African High-skilled and skilled

FGTausk	Gauteng African Semi- and Unskilled
FGTc	Gauteng Coloured and Asian
FGTw	Gauteng White
FMPaf	Mpumalanga African
FMPc	Mpumalanga Coloured and Asian
FMPw	Mpumalanga White
FLPafsk	Limpopo African High-skilled and skilled
FLPafusk	Limpopo African Semi- unskilled
FLPc	Limpopo Coloured and Asian
FLPw	Limpopo White
HWCaf	Western Cape African
HWCcls	Western Cape Asian and Coloured Lower Secondary and lower
HWCcus	Western Cape Asian and Coloured Upper Secondary and higher
HWCw	Western Cape White
HECafls	Eastern Cape African Agric or Lower Secondary and lower
HECafus	Eastern Cape African Upper Secondary and higher
HECc	Eastern Cape Asian and Coloured
HECw	Eastern Cape White
HNC1	Northern Cape African Primary and lower
HNC2	Northern Cape African Lower Secondary and higher
HNC3	Northern Cape Coloured and Asian Lower Secondary and lower
HNC4	Northern Cape Coloured and Asian Upper Secondary and higher
HNC5	Northern Cape White
HFSafls	Free State African Agric or Lower Secondary and lower
HFSafus	Free State African Upper Secondary and higher
HFSc	Free State Asian and Coloured
HFSw	Free State White
HKZafls	Kwazulu-Natal African Agric or Lower Secondary and lower
HKZafus	Kwazulu-Natal African Upper Secondary and higher
HKZasls	Kwazulu-Natal Asian Lower Secondary and lower
HKZasus	Kwazulu-Natal Asian Upper Secondary and higher
HKZc	Kwazulu-Natal Coloured
HKZw	Kwazulu-Natal White
HNWafls	North West African Agric or Lower Secondary and lower
HNWafus	North West African Upper Secondary and higher and higher
HNWc	North West Asian and Coloured
HNWw	North West White
HGTafls	Gauteng Agric or Lower Secondary and lower
HGTafus	Gauteng African Upper Secondary and higher
HGTc	Gauteng Asian and Coloured
HGTw	Gauteng White
HMPafls	Mpumalanga Agric or Lower Secondary and lower
HMPafus	Mpumalanga African Upper Secondary and higher
HMPc	Mpumalanga Asian and Coloured
HMPw	Mpumalanga White
HLPafls	Limpopo African Agric or Lower Secondary and lower
HLPafus	Limpopo African Upper Secondary and higher
HLPc	Limpopo Asian and Coloured

HLPw	Limpopo White
IMPTAX	Import duties
EXPTAX	Export tax
VATM	Value added tax on imports
VATD	Value added tax on domestic go
ECTAX	Excise duty
SALTAX	Sales Tax
SALSUB	Sales subsidies
INDTAX	Production taxes
INDREF	Production refunds or VAT
INDSUB	Production subsidies
FACTTAX	Factor Tax
DIRTAX	Direct income taxes
GOVT	Central Government
ENT	Business Enterprises
KAP	Savings
DSTOC	Stock Changes
ROW	Rest of the World
TOTAL	Account totals

Appendix 4C: GAMS code for CGE model:

```
EQUATION DECLARATIONS ##########################################

*Price block=================================================
 PMDEF(C)      domestic import price
 PEDEF(C)      domestic export price
 PDDDEF(C)      dem price for com'y c produced and sold domestically
 PQDEF(C)      value of sales in domestic market
 PXDEF(C)      value of marketed domestic output
 PADEF(A)      output price for activity a
 PINTADEF(A)    price of aggregate intermediate input
 PVADEF(A)      value-added price
 CPIDEF        consumer price index
 DPIDEF        domestic producer price index

*Production and trade block================================
 CESAGGPRD(A)    CES aggregate prod fn (if CES top nest)
 CESAGGFOC(A)    CES aggregate first-order condition (if CES top nest)
 LEOAGGINT(A)    Leontief aggreg intermed dem (if Leontief top nest)
 LEOAGGVA(A)     Leontief aggreg value-added dem (if Leontief top nest)
 CESVAPRD(A)     CES value-added production function
 CESVAFOC(F,A)   CES value-added first-order condition
 INTDEM(C,A)     intermediate demand for commodity c from activity a
 COMPRDFN(A,C)   production function for commodity c and activity a
 OUTAGGFN(C)     output aggregation function
 OUTAGGFOC(A,C)  first-order condition for output aggregation function
 CET(C)          CET function
 CET2(C)         domestic sales and exports for outputs without both
 ESUPPLY(C)      export supply
 ARMINGTON(C)    composite commodity aggregation function
 COSTMIN(C)      first-order condition for composite commodity cost min
 ARMINGTON2(C)   comp supply for com's without both dom. sales and imports
 QTDEM(C)        demand for transactions (trade and transport) services

*Institution block ========================================
 YFDEF(F)        factor incomes
 YIFDEF(INS,F)   factor incomes to domestic institutions
 YIDEF(INS)      total incomes of domest non-gov't institutions
 EHDEF(H)        household consumption expenditures
 TRIIDEF(INS,INSP) transfers to inst'on ins from inst'on insp
 HMDEM(C,H)      LES cons demand by hhd h for marketed commodity c
 HADEM(A,C,H)    LES cons demand by hhd h for home commodity c fr act a
 INVDEM(C)       fixed investment demand
 GOVDEM(C)       government consumption demand
 EGDEF           total government expenditures
 YGDEF           total government income

*System constraint block===================================
 COMEQUIL(C)     composite commodity market equilibrium
 FACEQUIL(F)     factor market equilibrium
 CURACCBAL       current account balance (of RoW)
 GOVBAL          government balance
 TINSDEF(INS)    direct tax rate for inst ins
 MPSDEF(INS)     marg prop to save for inst ins
 SAVINVBAL       savings-investment balance
 TABSEQ          total absorption
```

```
 INVABEQ       investment share in absorption
 GDABEQ        government consumption share in absorption
 OBJEQ         Objective function;

EQUATION DEFINITIONS ############################################

*Notational convention inside equations:
*Parameters and "invariably" fixed variables are in lower case.
*"Variable" variables are in upper case.

*Price block==============================================

 PMDEF(C)$CM(C)..
  PM(C) =E= pwm(C)*(1 + tm(C))*EXR + SUM(CT, PQ(CT)*icm(CT,C));

 PEDEF(C)$CE(C)..
  PE(C) =E= pwe(C)*(1 - te(C))*EXR - SUM(CT, PQ(CT)*ice(CT,C));

 PDDDEF(C)$CD(C).. PDD(C) =E= PDS(C) + SUM(CT, PQ(CT)*icd(CT,C));

 PQDEF(C)$(CD(C) OR CM(C))..
      PQ(C)*(1 - tq(c))*QQ(C) =E= PDD(C)*QD(C) + PM(C)*QM(C);

 PXDEF(C)$CX(C)..  PX(C)*QX(C) =E= PDS(C)*QD(C) + PE(C)*QE(C);

 PADEF(A)..  PA(A) =E= SUM(C, PXAC(A,C)*theta(A,C));

 PINTADEF(A).. PINTA(A) =E= SUM(C, PQ(C)*ica(C,A)) ;

 PVADEF(A)$QVA0(A)..  PA(A)*(1-ta(A))*QA(A) =E= PVA(A)*QVA(A) + PINTA(A)*QINTA(A) ;

 CPIDEF..  CPI =E= SUM(C, cwts(C)*PQ(C)) ;

*According to Melt Verskoor
* CPIDEF..  CPI =E= SUM(C, cwts(C)*PQ(C)/PQ0(C)) ;

 DPIDEF..  DPI =E= SUM(CD, dwts(CD)*PDS(CD)) ;


*Production and trade block================================

*CESAGGPRD and CESAGGFOC apply to activities with CES function at
*top of technology nest.

 CESAGGPRD(A)$ACES(A)..
   QA(A) =E= alphaa(A)*(deltaa(A)*QVA(A)**(-rhoa(A))
            + (1-deltaa(A))*QINTA(A)**(-rhoa(A)))**(-1/rhoa(A)) ;

 CESAGGFOC(A)$ACES(A)..
   QVA(A) =E= QINTA(A)*((PINTA(A)/PVA(A))*(deltaa(A)/
                         (1 - deltaa(A))))**(1/(1+rhoa(A))) ;


*LEOAGGINT and LEOAGGVA apply to activities with Leontief function at
*top of technology nest.

 LEOAGGINT(A)$ALEO(A)..  QINTA(A) =E= inta(A)*QA(A) ;

 LEOAGGVA(A)$ALEO(A)..  QVA(A) =E= iva(A)*QA(A) ;
```

```
*CESVAPRD, CESVAFOC, INTDEM apply at the bottom of the technology nest
*(for all activities).

 CESVAPRD(A)$QVA0(A)..
   QVA(A) =E= alphava(A)*(SUM(F,
                  deltava(F,A)*QF(F,A)**(-rhova(A))) )**(-1/rhova(A)) ;


 CESVAFOC(F,A)$deltava(F,A)..
   WF(F)*wfdist(F,A) =E=
   PVA(A)*(1-tva(A))
   * QVA(A) * SUM(FP, deltava(FP,A)*QF(FP,A)**(-rhova(A)) )**(-1)
   *deltava(F,A)*QF(F,A)**(-rhova(A)-1);

 INTDEM(C,A)$ica(C,A).. QINT(C,A) =E= ica(C,A)*QINTA(A);


 COMPRDFN(A,C)$theta(A,C)..
    QXAC(A,C) + SUM(H, QHA(A,C,H)) =E= theta(A,C)*QA(A) ;

 OUTAGGFN(C)$CX(C)..
   QX(C) =E= alphaac(C)*SUM(A, deltaac(A,C)*QXAC(A,C)
                                 **(-rhoac(C)))**(-1/rhoac(C));

 OUTAGGFOC(A,C)$deltaac(A,C)..
   PXAC(A,C) =E=
   PX(C)*QX(C) * SUM(AP, deltaac(AP,C)*QXAC(AP,C)**(-rhoac(C)) )**(-1)
   *deltaac(A,C)*QXAC(A,C)**(-rhoac(C)-1);

 CET(C)$(CE(C) AND CD(C))..
    QX(C) =E= alphat(C)*(deltat(C)*QE(C)**rhot(C) +
                     (1 - deltat(C))*QD(C)**rhot(C))**(1/rhot(C)) ;

  ESUPPLY(C)$(CE(C) AND CD(C))..
   QE(C) =E=  QD(C)*((PE(C)/PDS(C))*
              ((1 - deltat(C))/deltat(C)))**(1/(rhot(C)-1)) ;

 CET2(C)$( (CD(C) AND CEN(C)) OR (CE(C) AND CDN(C)) )..
   QX(C) =E= QD(C) + QE(C);


 ARMINGTON(C)$(CM(C) AND CD(C))..
   QQ(C) =E= alphaq(C)*(deltaq(C)*QM(C)**(-rhoq(C)) +
                  (1 -deltaq(C))*QD(C)**(-rhoq(C)))**(-1/rhoq(C)) ;

 COSTMIN(C)$(CM(C) AND CD(C))..
   QM(C) =E= QD(C)*((PDD(C)/PM(C))*(deltaq(C)/(1 - deltaq(C))))
                                        **(1/(1 + rhoq(C)));

 ARMINGTON2(C)$( (CD(C) AND CMN(C)) OR (CM(C) AND CDN(C)) )..
   QQ(C) =E= QD(C) + QM(C);

 QTDEM(C)$CT(C)..
  QT(C) =E= SUM(CP, icm(C,CP)*QM(CP)+ ice(C,CP)*QE(CP)+ icd(C,CP)*QD(CP));


*Institution block ========================================

 YFDEF(F)..  YF(F) =E= SUM(A, WF(F)*wfdist(F,A)*QF(F,A));
```

```
 YIFDEF(INSD,F)$shif(INSD,F)..
  YIF(INSD,F) =E= shif(INSD,F)*((1-tf(f))*YF(F) - trnsfr('ROW',F)*EXR);

 YIDEF(INSDNG)..
  YI(INSDNG) =E=
   SUM(F, YIF(INSDNG,F))  + SUM(INSDNGP, TRII(INSDNG,INSDNGP))
   + trnsfr(INSDNG,'GOV')*CPI + trnsfr(INSDNG,'ROW')*EXR;

 TRIIDEF(INSDNG,INSDNGP)$(shii(INSDNG,INSDNGP))..
  TRII(INSDNG,INSDNGP) =E= shii(INSDNG,INSDNGP)
         * (1 - MPS(INSDNGP)) * (1 - TINS(INSDNGP))* YI(INSDNGP);

 EHDEF(H)..
  EH(H) =E= (1 - SUM(INSDNG, shii(INSDNG,H))) * (1 - MPS(H))
                                    * (1 - TINS(H)) * YI(H);

 HMDEM(C,H)$betam(C,H)..
   PQ(C)*QH(C,H) =E=
    PQ(C)*gammam(C,H)
       + betam(C,H)*( EH(H) - SUM(CP, PQ(CP)*gammam(CP,H))
                    - SUM((A,CP), PXAC(A,CP)*gammah(A,CP,H))) ;

 HADEM(A,C,H)$betah(A,C,H)..
   PXAC(A,C)*QHA(A,C,H) =E=
     PXAC(A,C)*gammah(A,C,H)
             + betah(A,C,H)*(EH(H) - SUM(CP, PQ(CP)*gammam(CP,H))
                  - SUM((AP,CP), PXAC(AP,CP)*gammah(AP,CP,H))) ;

 INVDEM(C)$CINV(C)..  QINV(C) =E= IADJ*qbarinv(C);

 GOVDEM(C)..  QG(C) =E= GADJ*qbarg(C);

 YGDEF..
   YG =E= SUM(INSDNG, TINS(INSDNG)*YI(INSDNG))
        + SUM(f, tf(F)*YF(F))
        + SUM(A, tva(A)*PVA(A)*QVA(A))
        + SUM(A, ta(A)*PA(A)*QA(A))
        + SUM(C, tm(C)*pwm(C)*QM(C))*EXR
        + SUM(C, te(C)*pwe(C)*QE(C))*EXR
        + SUM(C, tq(C)*PQ(C)*QQ(C))
        + SUM(F, YIF('GOV',F))
        + trnsfr('GOV','ROW')*EXR;

 EGDEF..
   EG =E= SUM(C, PQ(C)*QG(C)) + SUM(INSDNG, trnsfr(INSDNG,'GOV'))*CPI;


*System constraint block===================================

 FACEQUIL(F)..  SUM(A, QF(F,A)) =E= QFS(F);

 COMEQUIL(C)..
   QQ(C) =E= SUM(A, QINT(C,A)) + SUM(H, QH(C,H)) + QG(C)
             + QINV(C) + qdst(C) + QT(C);

 CURACCBAL..
  SUM(C, pwm(C)*QM(C)) + SUM(F, trnsfr('ROW',F)) =E=
  SUM(C, pwe(C)*QE(C)) + SUM(INSD, trnsfr(INSD,'ROW')) + FSAV;
```

```
GOVBAL.. YG =E= EG + GSAV;

TINSDEF(INSDNG)..
 TINS(INSDNG) =E= tinsbar(INSDNG)*(1 + TINSADJ*tins01(INSDNG))
                + DTINS*tins01(INSDNG);

MPSDEF(INSDNG)..
 MPS(INSDNG)  =E= mpsbar(INSDNG)*(1 + MPSADJ*mps01(INSDNG))
                + DMPS*mps01(INSDNG);

SAVINVBAL..
  SUM(INSDNG, MPS(INSDNG) * (1 - TINS(INSDNG)) * YI(INSDNG))
   + GSAV + FSAV*EXR =E=
  SUM(C, PQ(C)*QINV(C)) + SUM(C, PQ(C)*qdst(C)) + WALRAS;

TABSEQ..
 TABS =E=
  SUM((C,H), PQ(C)*QH(C,H)) + SUM((A,C,H), PXAC(A,C)*QHA(A,C,H))
 + SUM(C, PQ(C)*QG(C)) + SUM(C, PQ(C)*QINV(C)) + SUM(C, PQ(C)*qdst(C));

INVABEQ.. INVSHR*TABS =E= SUM(C, PQ(C)*QINV(C)) + SUM(C, PQ(C)*qdst(C));

GDABEQ..  GOVSHR*TABS =E= SUM(C, PQ(C)*QG(C));

OBJEQ..   WALRASSQR   =E= WALRAS*WALRAS ;
```

Appendix 4D: GAMS code for CGE simulation

```
SET
 SIM  simulations
 /
 BASE      base simulation
 TARCUT1   50% cut in tariffs + flex gov sav + mobile factors
 TARCUTUE   50% cut in tariffs same as TARCUT1 + unemployment of unskilled labour
 PWMINCR   10% increase in import prices
 PWMINCRUE 10% increase in import prices + unemployment of unskilled labour
 PWEINCR   10% increase in export prices
 PWEDECR   10% decrease in export prices
 PWEINCRUE 10% increase in export prices
 PWEDECRUE 10% decrease in export prices
 /

 SIMCUR(SIM)     current simulations
 /
 BASE      base simulation
 TARCUT1   50% cut in tariffs + flex gov sav + mobile factors
 TARCUTUE  50% cut in tariffs same as TARCUT1 + unemployment of unskilled labour
 PWMINCR   10% increase in import prices
 PWMINCRUE 10% increase in import prices + unemployment of unskilled labour
 PWEINCR   10% increase in export prices
 PWEDECR   10% decrease in export prices
 PWEINCRUE 10% increase in export prices
 PWEDECRUE 10% decrease in export prices
/

 SIMBASINIT(SIM) simulations with variable initialized at base level
 SIMMCP(SIM)     simulations solved as MCP problems
 ;

*Variable initializatiion at base level may provide a better starting
*point for selected simulations (depending on the content of the
*preceding simulation).
 SIMBASINIT(SIM)   = NO;
 SIMBASINIT(SIM)   = YES;

*It is typically preferable to solve the MCP version of the model.
 SIMMCP(SIM)     = YES;

DISPLAY SIMCUR, SIMBASINIT;


*END: SETS FOR SIMULATIONS==========================================
*2. DEFINING EXPERIMENT PARAMETERS===================================

PARAMETERS
 TMSIM(C,SIM)  tariff rate for com c by sim

*Closure variables that may be changed exogenously in simulations
*The values defined for these parameters matter only if the related
*variable is fixed
 FSAVSIM(SIM)  foreign savings by sim (FCU)
 IADJSIM(SIM)  investment adjustment factor by sim
 EXRSIM(SIM)   exchange rate by sim
 GSAVSIM(SIM)  government savings by sim
 PWMSIM(C,SIM) price for imports of c in FCU
```

```
 ;

*Unless specified otherwise below, base values are used
 TMSIM(C,SIM)      = tm(C);
 FSAVSIM(SIM)      = FSAV0;
 IADJSIM(SIM)      = IADJ0;
 EXRSIM(SIM)       = EXR0;
 GSAVSIM(SIM)      = GSAV0;
 PWMSIM(C,SIM)     = pwm0(C);
 ALPHAVASIM(A,SIM) = alphava(A);
 PWESIM(C,SIM)     = pwe0(C);

*Specifiying non-base values for experiment parameters
 TMSIM(CIAGR,'TARCUT1')   = 0.5*TM0(CIAGR);
 TMSIM(CIAGR,'TARCUTUE')  = 0.5*TM0(CIAGR);
 PWMSIM('C4a','PWMINCR')  = 1.2*pwm0('C4a');
 PWMSIM('C4a','PWMINCRUE')  = 1.2*pwm0('C4a');
 ALPHAVASIM(A,SIM) = alphava(A) * 1.0;
 PWESIM('C1IJK','PWEDECR')    = 0.8*pwe0('C1IJK');
 PWESIM('C1IJK','PWEDECRUE')  = 0.8*pwe0('C1IJK');
 PWESIM('C1IJK','PWEINCR')    = 1.2*pwe0('C1IJK');
 PWESIM('C1IJK','PWEINCRUE')  = 1.2*pwe0('C1IJK');

DISPLAY
 TMSIM, PWMSIM,  PWESIM
 ;
*FSAVSIM, IADJSIM, GSAVSIM,ALPHAVASIM,

*END: DEFINING EXPERIMENT PARAMETERS================================
*3. DEFINING NUMERAIRE AND CLOSURES FOR MACRO SYSTEM CONSTRAINTS=====

*The selection of values for NUMERAIRE, SICLOS, ROWCLOS, and GOVCLOS
*in this section determines the selection of variables that are fixed
*and flexible inside the solution LOOP.

PARAMETERS

 NUMERAIRE(SIM)        numeraire
*NUMERAIRE = 1 ---> CPI is numeraire (and fixed) -- DPI is flexible
*NUMERAIRE = 2 ---> DPI is numeraire (and fixed) -- CPI is flexible
*Note that a fixed exchange rate value or any nominal value or price that is
*fixed in domestic currency is implicitly indexed to the numeraire.

 SICLOS(SIM) value for savings-investment closure
*SICLOS = 1 ---> inv-driven sav -- uniform mps rate point change for
*              selected ins
*SICLOS = 2 ---> inv-driven sav -- scaled mps for for selected ins
*SICLOS = 3 ---> inv is sav-driven
*SICLOS = 4 ---> inv is fixed abs share
*              - uniform mps rate point change (cf. 1)
*SICLOS = 5 ---> inv is fixed abs share - scaled mps (cf. 2)
*Note: SICLOS 4 and 5 are examples of balanced closures.

 ROWCLOS(SIM) value for rest-of-world closure
*ROWCLOS = 1 ---> exch rate is flexible, for savings are fixed
*ROWCLOS = 2 ---> exch rate is fixed   , for savings are flexible

 GOVCLOS(SIM) value for government closure
*GOVCLOS = 1 ---> gov savings are flexible, dir tax rate is fixed
*GOVCLOS = 2 ---> gov savings are fixed   ,
```

```
*               uniform dir tax rate point change for selected ins
*GOVCLOS = 3 ---> gov savings are fixed   ,
*               scaled dir tax rate for selected institutions

 MPS01SIM(INS,SIM)   0-1 par for potential flexing of savings rates
 TINS01SIM(INS,SIM)  0-1 par for potential flexing of dir tax rates
 ;


*NUMERAIRE, SICLOS, ROWCLOS, and GOVCLOS are set at default values
 NUMERAIRE(SIM)  = 1;
 SICLOS(SIM)     = 1;
 ROWCLOS(SIM)    = 1;
 GOVCLOS(SIM)    = 1;


$ontext
For closures with flexible savings or direct tax rates, the default is
that the rates of all domestic non-government institutions adjust. If
you deviate from the default, make sure that, for both parameters and
for simulations using the indicated closures, the value of at least one
element in INSDNG is unity. (If not, the parameters ERRMPS01 and
ERRTINS01 will generate errors.)
$offtext

 MPS01SIM(INSDNG,SIM)   = 1;
 TINS01SIM(INSDNG,SIM)  = 1;

*Here: overwrite values for NUMERAIRE, SICLOS, ROWCLOS, and GOVCLOS for
*selected simulations

* NUMERAIRE('DEVAL') = 2;
 GOVCLOS('TARCUT1') = 1;
* GOVCLOS('TARCUT2') = 1;
* ROWCLOS('DEVAL')   = 2;
* SICLOS('DEVAL')     = 5;


PARAMETERS

 ERRMPS01(SIM)  UNDF if MPS01SIM not unity for at least one INSDNG
*In order for SICLOS 1, 2, 4 and 5 to work, MPS01SIM has to have a value of
*unity for at least one element in INSDNG for every SIM. If this is not
*the case, an error is generated. Solution: change the definition if
*MPS01SIM.

 ERRTINS01(SIM)  UNDF if TINS01SIM not unity for at least one INSDNG
*In order for GOVCLOS 2 and 3 to work, TINS01SIM has to have a value of
*unity for at least one element in INSDNG for every SIM. If this is not
*the case, an error is generated. Solution: change the definition if
*TINS01SIM.
 ;

 ERRMPS01(SIM)$(((SICLOS(SIM) EQ 1) OR (SICLOS(SIM) EQ 2) OR (SICLOS(SIM) EQ 4)
OR (SICLOS(SIM) EQ 5))
  AND (SUM(INSDNG$(MPS01SIM(INSDNG,SIM) EQ 1), 1) LT 1)) = 1/0;

 ERRTINS01(SIM)$(((GOVCLOS(SIM) EQ 2) OR (GOVCLOS(SIM) EQ 3))
  AND (SUM(INSDNG$(TINS01SIM(INSDNG,SIM) EQ 1), 1) LT 1)) = 1/0;
```

```
DISPLAY
 NUMERAIRE, SICLOS, GOVCLOS, ROWCLOS, MPS01SIM, TINS01SIM, ERRMPS01,
ERRTINS01
 ;

PARAMETER
 ERRMPSEQ1(INS,SIM) UNDF error if institution with MPS at unity has flexible MPS
$ontext
Savings-investment closures that involve adjustments of the MPS of an
element in INSDNG for which mpsbar is at (or very close) to unity will
not work (since the total spending of such an institution will deviate
from its total income whenever the MPS changes). The user should review
the SAM and other data sources to assess whether an mpsbar of unity is
plausible and change the SAM if it is not. If it is plausible, it would
be necessary to give such an institution a value of zero for MPS01SIM
under savings-investment closures with a flexible MPS for one or more
other institutions.

This parameter is first defined in REPLOOP.INC and redefined after the
LOOP in a manner that generates an UNDF error if the error is present.

$offtext

*END: DEFINING CLOSURES FOR MACRO SYSTEM CONSTRAINTS=================
*4. DEFINING CLOSURES FOR FACTOR MARKETS=============================

*Inside the solution loop, the selection of values for FMOBFE, FACTFE,
*and FMOBUE determine the selection of variables that are fixed
*and flexible.


PARAMETERS
 FMOBFE(F,SIM)  factor f is fully employed & mobile in sim
 FACTFE(F,SIM)  factor f is fully employed & activity-specific in sim
 FMOBUE(F,SIM)  factor f is unemployed & mobile in sim
 ;
*Default specification of factor market closures
*Note that, for every simulation, every factor should have a non-zero
*value for exactly one of the three parameters.

 FMOBFE(FLAB,SIM) = 1;
* FMOBFE(FLND,SIM) = 1;
 FACTFE(FLND,SIM) = 1;
 FMOBFE(FCAP,SIM) = 1;
 FMOBUE(F,SIM)    = 0;

* FMOBFE(FLAB,SIM) = 1;
* FMOBFE(FLND,SIM) = 1;
* FACTFE(FLAB,SIM) = 1;
* FMOBUE(FCAP,SIM) = 1;
* FACTFE(FCAP,SIM) = 1;

*If no value is specified for a factor, impose FMOBFE:
 FMOBFE(F,SIM)$(FMOBFE(F,SIM) + FACTFE(F,SIM) + FMOBUE(F,SIM) EQ 0) = 1;



*Here: overwrite values for FMOBFE, FACTFE, and FMOBUE for selected
*factors and simulations
```

```
 FMOBFE(FLABUS,'TARCUTUE')  = 0;
 FMOBUE(FLABUS,'TARCUTUE' ) = 1;
 FMOBFE(FLABUS,'PWMINCRUE') = 0;
 FMOBUE(FLABUS,'PWMINCRUE') = 1;
 FMOBFE(FLABUS,'PWEINCRUE') = 0;
 FMOBUE(FLABUS,'PWEINCRUE') = 1;
 FMOBFE(FLABUS,'PWEDECRUE') = 0;
 FMOBUE(FLABUS,'PWEDECRUE') = 1;


*Checking for errors in factor market closures

PARAMETER
 ERRFCLOS(F,SIM) UNDF error if not exactly one closure by f and sim
*Error if any factor f, in each simulation, does not have a non-zero
*value for exactly one of the three parameters FMOBFE, FACTFE, FMOBUE.
 ;
 ERRFCLOS(F,SIM)$(FMOBFE(F,SIM)+ FACTFE(F,SIM)+ FMOBUE(F,SIM) NE 1) = 1/0;

DISPLAY ERRFCLOS, FMOBFE, FACTFE, FMOBUE;


*5. REPORT SETUP=================================================

$INCLUDE 2REPSETUP.INC

$STITLE Input file: SIM101.GMS. Standard CGE modeling system, Version 1.01

*================================================================
*6. L O O P=========================================================
*================================================================
LOOP(SIMCUR,

*This include statement is optional. It may facilitate solver
*performance by providing better starting point.
IF(SIMBASINIT(SIMCUR),
$INCLUDE 1VARINIT.INC
);

$STITLE Input file: SIM101.GMS. Standard CGE modeling system, Version 1.01

*IMPOSING PARAMETER  & FIXED VARIABLE VALUES FOR EXPERIMENTS=========
*In this section, changes in experiment parameters and fixed
*variables are imposed, except for changes in fixed variables related to
*closures, which are handled in the next section.

 tm(C)      = TMSIM(C,SIMCUR);
 PWM.FX(C)  = PWMSIM(C,SIMCUR);
 alphava(A) = ALPHAVASIM(A,SIMCUR);
 PWE.FX(C)  = PWESIM(C,SIMCUR);
* PX.FX('C1IJK') = PCSIM('C1IJK',SIMCUR);

*IMPOSING CLOSURES FOR SYSTEM CONSTRAINTS===========================

*Selecting institutions with potentially flexible savings and direct
*tax rates. This setting only matters for some of the alternative
*savings-investment and government closures.
 mps01(INSDNG)  = MPS01SIM(INSDNG,SIMCUR);
 tins01(INSDNG) = TINS01SIM(INSDNG,SIMCUR);
```

```
*-------------
IF(NUMERAIRE(SIMCUR) EQ 1,
 CPI.FX = CPI0;
 DPI.LO = -INF;
 DPI.UP = +INF;
 DPI.L  = DPI0;  );

IF(NUMERAIRE(SIMCUR) EQ 2,
 DPI.FX = DPI0;
 CPI.LO = -INF;
 CPI.UP = +INF;
 CPI.L  = CPI0;  );

*-------------

IF(SICLOS(SIMCUR) EQ 1,
*Investment-driven savings
*Uniform MPS rate point change for selected ins
*Fixed investment demand quantity adjustment factors
*Flexible absorption shares for investment demand
 MPSADJ.FX = MPSADJ0;
 DMPS.LO = -INF; DMPS.UP = +INF; DMPS.L = DMPS0;
 IADJ.FX       = IADJSIM(SIMCUR);
 INVSHR.LO = -INF; INVSHR.UP = +INF; INVSHR.L = INVSHR0;
*Fixed government demand quantity adjustment factors
*Flexible absorption share for government demand
 GADJ.FX    = GADJ0;
 GOVSHR.LO = -INF; GOVSHR.UP = +INF; GOVSHR.L = GOVSHR0;
 );

IF(SICLOS(SIMCUR) EQ 2,
*Investment-driven savings
*Scaled MPS for selected institutions
*Fixed investment demand quantity adjustment factors
*Flexible absorption shares for investment demand
 MPSADJ.LO = -INF; MPSADJ.UP = +INF; MPSADJ.L = MPSADJ0;
 DMPS.FX = DMPS0;
 IADJ.FX = IADJSIM(SIMCUR);
 INVSHR.LO = -INF; INVSHR.UP = +INF; INVSHR.L = INVSHR0;
*Fixed government demand quantity adjustment factors
*Flexible absorption share for government demand
 GADJ.FX    = GADJ0;
 GOVSHR.LO = -INF; GOVSHR.UP = +INF; GOVSHR.L = GOVSHR0;
 );

IF(SICLOS(SIMCUR) EQ 3,
*Savings-driven investment
*Fixed marginal savings propensities
*Flexible investment demand quantity adjustment factors
*Flexible absorption shares for investment demand
 MPSADJ.FX = MPSADJ0;
 DMPS.FX = DMPS0;
 IADJ.LO = -INF; IADJ.UP = +INF;  IADJ.L = IADJ0;
 INVSHR.LO = -INF; INVSHR.UP = +INF; INVSHR.L = INVSHR0;
*Fixed government demand quantity adjustment factors
*Flexible absorption share for government demand
 GADJ.FX    = GADJ0;
 GOVSHR.LO = -INF; GOVSHR.UP = +INF; GOVSHR.L = GOVSHR0;
 );
```

```
IF(SICLOS(SIMCUR) EQ 4,
*Balanced closure.
*Uniform MPS rate point change for selected ins
*Flexible investment demand quantity adjustment factors
*Fixed absorption shares for investment demand
 MPSADJ.FX = MPSADJ0;
 DMPS.LO = -INF; DMPS.UP = +INF; DMPS.L = DMPS0;
 IADJ.LO = -INF; IADJ.UP = +INF;  IADJ.L = IADJ0;
 INVSHR.FX = INVSHR0;
*Flexible government demand quantity adjustment factors
*Fixed absorption share for government demand
 GADJ.LO = -INF; GADJ.UP = +INF;  GADJ.L = GADJ0;
 GOVSHR.FX = GOVSHR0;
 );

IF(SICLOS(SIMCUR) EQ 5,
*Balanced closure.
*Scaled MPS for selected institutions
*Flexible investment demand quantity adjustment factors
*Fixed absorption shares for investment demand
 MPSADJ.LO = -INF; MPSADJ.UP = +INF; MPSADJ.L = MPSADJ0;
 DMPS.FX = DMPS0;
 IADJ.LO = -INF; IADJ.UP = +INF;  IADJ.L = IADJ0;
 INVSHR.FX = INVSHR0;
*Flexible government demand quantity adjustment factors
*Fixed absorption share for government demand
 GADJ.LO = -INF; GADJ.UP = +INF;  GADJ.L = GADJ0;
 GOVSHR.FX = GOVSHR0;
 );

*-------------

IF(GOVCLOS(SIMCUR) EQ 1,
*Fixed direct tax rates
*Flexible government savings
 TINSADJ.FX = TINSADJ0;
 DTINS.FX = DTINS0;
 GSAV.LO = -INF; GSAV.UP = +INF; GSAV.L = GSAV0;
 );

IF(GOVCLOS(SIMCUR) EQ 2,
*Uniform direct tax rate point change for selected institutions
*Fixed government savings
 TINSADJ.FX = TINSADJ0;
 DTINS.LO = -INF; DTINS.UP = +INF; DTINS.L = DTINS0;
 GSAV.FX = GSAVSIM(SIMCUR);
 );

IF(GOVCLOS(SIMCUR) EQ 3,
*Scaled direct tax rates for selected institutions
*Fixed government savings
 TINSADJ.LO = -INF; TINSADJ.UP = +INF; TINSADJ.L = TINSADJ0;
 DTINS.FX = DTINS0;
 GSAV.FX = GSAVSIM(SIMCUR);
 );

*-------------

IF(ROWCLOS(SIMCUR) EQ 1,
*Fixed foreign savings -- flexible exchange rate
```

```
 FSAV.FX = FSAVSIM(SIMCUR);
 EXR.LO  = -INF; EXR.UP  = +INF; EXR.L   = EXR0;
 );

IF(ROWCLOS(SIMCUR) EQ 2,
*Fixed exchange rate -- flexible foreign savings
 EXR.FX = EXRSIM(SIMCUR);
 FSAV.LO = -INF; FSAV.UP = +INF; FSAV.L = FSAV0;
 );

*---------------------------------------------------------------------
*Loop over all factors for alternative factor-market closures.
LOOP(F,

*---
*Factors with FMOBFE(F,SIMCUR) = 1 are fully employed and mobile between
*activities. WF(F) is the market-clearing variable each factor.

IF(FMOBFE(F,SIMCUR) EQ 1,

 WFDIST.FX(F,A)      = WFDIST0(F,A);
 QFS.FX(F)          = QFS0(F);

 WF.LO(F)           = -INF;
 WF.UP(F)           = +INF;
 WF.L(F)            = WF0(F);

 QF.LO(F,A)$QF0(F,A) = -INF;
 QF.UP(F,A)$QF0(F,A) = +INF;
 QF.L(F,A)$QF0(F,A)  = QF0(F,A); );

*---
*Factors with FACTFE(F,SIMCUR) = 1 are fully employed and
*activity-specific. WFDIST(F,A) is the clearing variable, one for each
*segment of the factor market.

IF(FACTFE(F,SIMCUR) EQ 1,

 WF.FX(F)              = WF0(F);
 QF.FX(F,A)            = QF0(F,A);

 WFDIST.LO(F,A)$QF0(F,A) = -INF;
 WFDIST.UP(F,A)$QF0(F,A) = +INF;
 WFDIST.L(F,A)$QF0(F,A)  = WFDIST0(F,A);

 QFS.LO(F)             = -INF;
 QFS.UP(F)             = +INF;
 QFS.L(F)              = QFS0(F); );

*---
*Factors with FMOBUE(F,SIMCUR) = 1 are unemployed and mobile. For each
*activity, the wage, WFDIST(F,A)*WF(F), is fixed. QFS(F) is the
*market-clearing variable for the unified labor market.

IF(FMOBUE(F,SIMCUR) EQ 1,

 WFDIST.FX(F,A)      = WFDIST0(F,A);
 WF.FX(F)            = WF0(F);

 QF.LO(F,A)$QF0(F,A) = -INF;
```

```
 QF.UP(F,A)$QF0(F,A) = +INF;
 QF.L(F,A)$QF0(F,A)  = QF0(F,A);

 QFS.LO(F)          = -INF;
 QFS.UP(F)          = +INF;
 QFS.L(F)          = QFS0(F); );
*---
 );
*End loop for factor-market closures.

*SOLVING==============================================================


IF(SIMMCP(SIMCUR),
 SOLVE STANDCGE USING MCP;
ELSE
 SOLVE NLPCGE MINIMIZING WALRASSQR USING NLP;
 );


*DEFINING REPORT VALUES FOR SIMCUR====================================

$BATINCLUDE 2REPLOOP.INC SIMCUR

$STITLE Input file: SIM101.GMS. Standard CGE modeling system, Version 1.01

 );


*====================================================================
*END: L O O P========================================================
*====================================================================

*7. COMPUTING PERCENTAGE CHANGE FOR REPORT PARAMETERS================

$INCLUDE 2REPPERC.INC


$STITLE Input file: SIM101.GMS. Standard CGE modeling system, Version 1.01

*8. CHECKING FOR ERRORS IN SOLUTION AND REPORT PARAMETERS============


*If error in the negative price/quantity segment, one or more solution prices
*or quantities are negative.

NEGPWARN(C,SIM)$
 ((PDDX(C,SIM) LT 0) OR (PDSX(C,SIM) LT 0) OR
  (PEX(C,SIM)  LT 0) OR (PMX(C,SIM) LT 0)  OR
  (PQX(C,SIM) LT 0)  OR (PWEX(C,SIM) LT 0) OR
  (PWMX(C,SIM) LT 0) OR (PXX(C,SIM) LT 0) OR
  (SMIN(A, PXACX(A,C,SIM)) LT 0) )
  = 1/0;

NEGQWARN(C,SIM)$
  ((QDX(C,SIM) LT 0) OR (QEX(C,SIM)  LT 0) OR
  (QMX(C,SIM) LT 0)  OR (QQX(C,SIM) LT 0) OR
```

```
 (QEX(C,SIM) LT 0)  OR (QXX(C,SIM) LT 0) OR
 (SMIN(A, QXACX(A,C,SIM)) LT 0) )
 = 1/0;

NEGWFWARN(F,SIM)$
 ((WFX(F,SIM) LT 0) OR (SMIN(A, WFDISTX(F,A,SIM)) LT 0) )
 = 1/0;

NEGQFWARN(F,SIM)$
 ((QFSX(F,SIM) LT 0) OR (SMIN(A, QFX(F,A,SIM)) LT 0) )
 = 1/0;


*If error here, check displays of SAMBUDGAP and GDPGAP to find it and
*fix it.
 GAPWARN(SIM)
  $(SUM(SAC, SAMBUDGAP(SAC,'TOTAL',SIM)) + GDPGAP(SIM) GT 0.0001) = 1/0;

*If error here, SOLVEREP reports illegal values.
 SOLVEWARN(SOLVEIND,MODTYPE,SIM)
  $(SOLVEREP(SOLVEIND,MODTYPE,SIM) GT SOLVEMAX(SOLVEIND,MODTYPE)) = 1/0;

*If error here, check displays of SAMBUDGAP for hints about the source
 WALRASWARN(SIM)$(ABS(WALRASX(SIM)) GT 0.001) = 1/0;

*If error here, check explanation above where ERRMPSEQ1 is declared.
 ERRMPSEQ1(INSDNG,SIM)$ERRMPSEQ1(INSDNG,SIM) = 1/0;


*9. DISPLAYING REPORTS================================================

OPTION
 QFX:3:1:1    , QHX:3:1:1      , QHAX:3:2:1, QINTX:3:1:1  , WFAX:3:1:1
 WFAX:3:1:1   , WFDISTX:3:1:1  , YFX:3:1:1

 QFXP:3:1:1   , QHXP:3:1:1     , QHAXP:3:2:1, QINTXP:3:1:1, WFAXP:3:1:1
 WFAXP:3:1:1  , WFDISTXP:3:1:1 , YFXP:3:1:1

 SAMBUD:3:1:1 , SAMBUDP:3:1:1
 GDPTAB1:3:1:1, GDPTAB1P:3:1:1
 GDPTAB2:3:1:1, GDPTAB2P:3:1:1
 MACCLOS:0,     FACCLOS:0:1:1
 SOLVEREP:0:1:1
 ;


DISPLAY
*Values for all model variables
CPIX    , DPIX     , DMPSX    , DTINSX   , EGX      , EHX      , EXRX
FSAVX   , GADJX    , GOVSHRX  , GSAVX    , IADJX    , INVSHRX  , MPSX
MPSADJX , PAX      , PDDX     , PDSX     , PEX      , PINTAX   , PMX
PQX     , PVAX     , PWEX     , PWMX     , PXX      , PXACX    , QAX
QDX     , QEX      , QFX      , QFSX     , QGX      , QHX      , QHAX
QINTX   , QINTAX   , QINVX    , QMX      , QQX      , QTX      , QVAX
QXX     , QXACX    , TABSX    , TINSX    , TINSADJX , TRIIX    , WALRASX
WFX     , WFDISTX  , YFX      , YGX      , YIFX     , YIX

*% change for all model variables
CPIXP   , DPIXP    , EGXP     , EHXP     , EXRXP    , FSAVXP   , GADJXP
GOVSHRXP, GSAVXP   , IADJXP   , INVSHRXP , MPSXP    , PAXP     , PDDXP
```

```
PDSXP   , PEXP     , PINTAXP  , PMXP     , PQXP     , PVAXP    , PWEXP
PWMXP   , PXXP     , PXACXP   , QAXP     , QDXP     , QEXP     , QFXP
QFSXP   , QGXP     , QHXP     , QHAXP    , QINTXP   , QINTAXP  , QINVXP
QMXP    , QQXP     , QTXP     , QVAXP    , QXXP     , QXACXP   , TABSXP
TINSXP  , TRIIXP   , WFAXP    , WFXP     , WFDISTXP , YFXP     , YGXP
YIFXP   , YIXP, theta

*Other displays
SAMBUD  ,  SAMBUDP , GDPTAB1  , GDPTAB1P , GDPTAB2  , GDPTAB2P

"The parameters MACCLOS and FACCLOS, and the sets ACES and ALEO"
"indicate the values for model features with user choice."

 MACCLOS
 "For GOV"
 "  1 -> gov savings are flexible, dir tax rate is fixed"
 "  2 -> gov savings are fixed"
 "       uniform dir tax rate point chng for selected ins"
 "  3 -> gov savings are fixed"
 "       scaled dir tax rate for selected institutions"
 ""
 "For ROW"
 "  1 -> exch rate is flexible, for savings are fixed"
 "  2 -> exch rate is fixed   , for savings are flexible"
 ""
 "For SAVINV"
  "1 -> inv-driven sav -- uniform mps rate point chng for selected ins"
  "2 -> inv-driven sav -- scaled mps for selected ins"
  "3 -> inv is sav-driven"
  "4 -> inv is fixed abs share - uniform mps rate chng (cf. 1)"
  "5 -> inv is fixed abs share - scaled mps (cf. 2)"
 ""
 FACCLOS
 "FMOBFE = 1 -> mobile and fully employed"
 "FACTFE = 1 -> activity-specific and fully employed"
 "FMOBUE = 1 -> mobile and unemployed"

 ACES
 "Activities in ACES have a CES aggregation function at the top of"
 "the technology nest."

 ALEO
 "Activities in ALEO have a Leontief aggregation function at the top of"
 "the technology nest."

 SIMBASINIT
 "For simulations in SIMBASINIT, the variables are initialized at"
 "base levels."

SAMBUDGAP , GDPGAP  ,

SOLVEREP

"MODEL STATUS:"
" 1 OPTIMAL"
" 2 LOCALLY OPTIMAL"
" 3 UNBOUNDED"
" 4 INFEASIBLE"
" 5 LOCALLY INFEASIBLE"
" 6 INTERMEDIATE INFEASIBLE"
```

```
" 7 INTERMEDIATE NON-OPTIMAL"
" 8 INTEGER SOLUTION"
" 9 INTERMEDIATE NON-INTEGER"
"10 INTEGER INFEASIBLE"
"11 (UNUSED)"
"12 ERROR UNKNOWN"
"13 ERROR NO SOLUTION"
""
"SOLVER STATUS:"
" 1 NORMAL COMPLETION"
" 2 ITERATION INTERRUPT"
" 3 RESOURCE INTERRUPT"
" 4 TERMINATED BY SOLVER"
" 5 EVALUATION ERROR LIMIT"
" 6 UNKNOWN"
" 7 (UNUSED)"
" 8 ERROR PREPROCESSOR ERROR"
" 9 ERROR SETUP FAILURE"
"10 ERROR SOLVER FAILURE"
"11 ERROR INTERNAL SOLVER ERROR"
"12 ERROR POST-PROCESSOR ERROR"
"13 ERROR SYSTEM FAILURE"
""
"NUM-REDEFEQ shows the number of redefined equations (should be zero)"
""
SOLVEWARN
"If error(s) (UNDF), one or more SOLVEREP values are illegal."
""
NEGPWARN, NEGQWARN, NEGWFWARN, NEGQFWARN
"Negative prices and quantities are economically illegal"
""
GAPWARN, WALRASWARN,
""
ERRMPSEQ1
"See the explanation where ERRMPSEQ1 is declared."
;
*$ontext
$INCLUDE 2REPSUM.INC

$STITLE Input file: SIM101.GMS. Standard CGE modeling system, Version 1.01



*Results to Excel via GDX
execute_unload "data_to_GDX" PDDXP, PEXP;
*Extra data na excell
Execute "GDXXRW data_to_GDX.gdx o=Extravariables.xls par=PEXP rng=PEXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Extravariables.xls par=PDDXP rng=PDDXP!a2 cdim=1 rdim=1";


$exit;
execute_unload "data_to_GDX" GDPTAB1, GDPTAB1p, CPIXP, GDPTAB2, GDPTAB2p, QHTAB, QATAB, PATAB,
DPIX, EHXP, QHX, QVAX, QXX, WFX, YFX, YGX, YIFX, YIX, EXRXP, MPSXP, PXACXP, QAXP, QEXP, QFXP, QHXP,
QINTXP, QMXP, QVAXP, QXXP, QXACXP, TINSXP, WFAXP, WFDISTXP, YFXP, YGXP, YIFXP, YIXP, GDPTAB2P, IC,
```

EV, PATAB, PVAXP, PQXP, GOVSHRXP, GSAVXP, PDSXP, PINTAXP, PMXP, QDXP, QQXP, QFSXP, EGXP;

Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=GDPTAB1 rng=GDPTAB1!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=GDPTAB1p rng=GDPTAB1p!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=CPIXp rng=CPIXp!a2 cdim=0 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=GDPTAB2 rng=GDPTAB2!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=GDPTAB2p rng=GDPTAB2p!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QHTAB rng=QHTAB!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QATAB rng=QATAB!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=PATAB rng=PATAB!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=DPIX rng=DPIX!a2 cdim=1 rdim=0";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=EHXP rng=EHXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QHX rng=QHX!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QVAX rng=QVAX!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QXX rng=QXX!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=WFX rng=WFX!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=YFX rng=YFX!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=YGX rng=YGX!a2 cdim=1 rdim=0";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=YIFX rng=YIFX!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=YIX rng=YIX!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=EXRXP rng=EXRXP!a2 cdim=1 rdim=0";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=MPSXP rng=MPSXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=PXACXP rng=PXACXP!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QAXP rng=QAXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QEXP rng=QEXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QFXP rng=QFXP!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QHXP rng=QHXP!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QINTXP rng=QINTXP!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QMXP rng=QMXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QVAXP rng=QVAXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QXXP rng=QXXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QXACXP rng=QXACXP!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=TINSXP rng=TINSXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=WFAXP rng=WFAXP!a2 cdim=1 rdim=2";

```
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=WFDISTXP rng=WFDISTXP!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=YFXP rng=YFXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=YGXP rng=YGXP!a2 cdim=1 rdim=0";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=YIFXP rng=YIFXP!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=YIXP rng=YIXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=GDPTAB2P rng=GDPTAB2P!a2 cdim=1 rdim=2";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=IC rng=IC!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=EV rng=EV!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=PATAB rng=PATAB1!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=PVAXP rng=PVAXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=PQXP rng=PQXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=GOVSHRXP rng=GOVSHRXP!a2 cdim=1 rdim=0";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=GSAVXP rng=GSAVXP!a2 cdim=1 rdim=0";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=PDSXP rng=PDSXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=PINTAXP rng=PINTAXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=PMXP rng=PMXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QDXP rng=QDXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QQXP rng=QQXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=QFSXP rng=QFSXP!a2 cdim=1 rdim=1";
Execute "GDXXRW data_to_GDX.gdx o=Results1.xls par=EGXP rng=EGXP!a2 cdim=1 rdim=0"
```