Science-Policy Interface to Mitigate Water Scarcity in India: An Assessment of Virtual Water Flows

Thesis submitted in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

by

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DECLARATION

I, Ms Suparana Katyaini, hereby declare that the matter embodied in this thesis is the result of investigations carried out by me in the Department of Humanities and Social Sciences, Indian Institute of Technology Guwahati, under the supervision and guidance of Dr. Anamika Barua.

In keeping with the general practice of reporting observations, due acknowledgements have been made wherever the work described is based on the findings of other investigators. The sources of secondary data utilized in this thesis are duly acknowledged.

Suparna

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CERTIFICATE

This is to certify that the thesis entitled "**Science-Policy Interface to Mitigate Water Scarcity in India: An Assessment of Virtual Water Flows**" submitted by Ms. Suparana Katyaini, Roll No. 11614104, for the award of degree of Doctor of Philosophy in the Department of Humanities and Social Sciences of Indian Institute of Technology Guwahati, embodies bonafide record of research work carried out under my supervision and guidance. The collection of materials from the secondary sources has also been done by Ms. Suparana Katyaini herself. All assistance received by the researcher has been duly acknowledged.

The present thesis or any part thereof has not been submitted to any other University for the award of any degree or diploma.

Dr. Anamika Barua
Associate Professor
(Thesis Supervisor)

DEDICATION

‘To my parents, with love and gratitude’

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ABSTRACT

Freshwater resources are essential for functioning of the economy, environment and society. From the perspective of sustainable development, the economy is considered as a subset of the environment. Therefore, freshwater resources act as both the source to, and the sink of the economy. Water security integrates the role of freshwater resources as a source as well as the sink of economy, through emphasis on 'sustainable use' of freshwater. Sustainable use of freshwater resources necessitates strengthening of science-policy interface to bridge the knowledge-governance gap in translating scientific knowledge into policy actions.

Virtual water (VW), which is an indicator of freshwater embodied in goods and services, was developed to induce and enhance sustainable use of freshwater resources in water-scarce regions of the world. VW-flows concept is at the science-policy interface. This is because it is based on the rationales of 'distribution of water scarcity' among regions with different water endowments, enhancing 'global water use efficiency' and 'net water savings'.

Sustainable use of freshwater resources is considered crucial for mitigating water scarcity, especially in emerging economies, like India. This is because while achieving higher economic growth and development, India's water sector is facing persistent challenges, as a result of which India has become the largest global freshwater user despite high water scarcity. The highest water using economic sector is India is agriculture, as it uses approximately 65-70% of freshwater resources. The sector is also crucial for food security and livelihood security. With many regions in India facing water scarcity, there is a concern over sustainable water use in agriculture.

With this research background, the thesis aimed to carry out an assessment of inter-state VW-flows embedded in two major categories of agriculture goods, i.e., food grains and oilseeds, in India to quantify net water savings/losses of the state. The inter-state VW-flows

assessment was carried out for two important phases of agriculture, i.e., *post-reforms period (1996-2005),* the *period of recovery (2005-2011) up to 2014.* These periods were considered crucial for understanding the sustainability of inter-state VW-flows because they represent the period of transformation in water policy of India towards sustainability and water security, in addition to, recovery in agriculture growth after the reforms. The thesis also aimed to link these net water savings/losses of the states with their respective water scarcity levels, and water policies to identify the sustainability of VW-flows, i.e., whether the VW-flows are leading to the distribution of water scarcity or not. Therefore, the research intended to *firstly* provide evidence for mainstreaming water as a factor of production in policy decisions for sustainable use of freshwater resources. *Secondly,* to emphasize the importance of science-policy interface for the formulation of well-informed policies in order to address the issue of water scarcity adequately.

Interestingly, the findings of water scarcity assessment reflect that there is a variation in water scarcity of states in India. It ranges from low to moderate water scarcity in states of North-East zone; moderate in states of Central and East; moderate to high in states of North, South, and West; to high water scarcity in states of South, North, and West zones. It is crucial to emphasize here that the states experiencing moderate to high and high water scarcity are also major producers of food grains and oilseeds. This leads to a concern of aggravation of water scarcity with continued production of food grains and oilseeds.

The inter-state VW-flows assessment revealed that there were net water savings of 89235 GL, and net water losses of -2124 GL due to the inter-state movement of food grains,and oilseed during post reforms period (1996-2005), respectively. The water savings increased to 207452974 GL and 84504 GL through inter-state movement of food grains,and oilseed in the period of recovery up to 2014 (2005-2014), respectively. This is attributed to increase in quantum of inter-state movement of food grains and oilseeds, yield, and water productivity.

At sub-national scale, unsustainable flows are seen as major VW-flows embedded in food grains from highly water-scarce North to highly water-scarce West and South, which is not distributing water scarcity. Unsustainable VW-flows embedded in oilseeds are from highly water-scarce South to North. The driving force of net VW- imports and VW-exports is larger population and arable land, respectively. As a result of inter-state movement of food grains and oilseeds during the post-reforms period (1996-2005), Maharashtra had the highest water savings while Punjab had the highest water losses. During 2005-2014, Tamil Nadu had the highest water savings, while Punjab continued to have the highest water losses. While both, Maharashtra and Tamil Nadu, water savings states in the two periods, regulate and manage water resources through state water policies, Punjab, the water losing state in both the periods, does not.

Linking the finding of net water savings/losses of the states with their respective water scarcity levels, and water policies revealed that absence of state-specific water policy cripples sustainable use of freshwater resources and water management, for instance, in Punjab. Based on five key indicators of science-policy interface - water scarcity inducers, water allocation priorities, water use efficiency, water savings, and stakeholder's participation and water literacy to mitigate water scarcity, it can be inferred that there is a need to rethink water policy to strengthen science-policy interface which would enable formulation of evidence-based water policies as well as effective implementation.

Therefore, the research argues that internalizing water as a factor of production (water as a source and a sink to the economy), i.e. through VW research, in policy decisions on production, and inter-state movement of food grains and oilseeds is essential for sustainable use of land and water to mitigate water scarcity; and it is crucial to strengthen the science-policy interface for formulation of well-informed policies in order to address the issue of water scarcity adequately.

LIST OF PUBLICATIONS

<u>Referred Publications (Journals)</u>

Katyaini, S., and Barua, A.,(2016). Water Policy at science-policy interface - challenges and opportunities for India. *Water Policy*, 18 (2), pp.288-303. Available at: http://www.iwaponline.com/wp/up/wp2015086.htm

Barua, A., **Katyaini, S**., Mili, B., and Gooch, P., (2013).Climate Change and Poverty-building resilience of rural mountain communities in South Sikkim, eastern Himalaya, India, *Regional Environment Change*, 14 (1), pp. 267–280.

Katyaini, S., Tripathi, P. & Barua, A., (2014). Application of an innovative and holistic water resources management instrument at a decentralized administrative level - a case of Maharashtra, India, *International Water Resources Association (IWRA) (India),* 3(1), pp. 12-21.

Barua, A., **Katyaini, S**. and Mili, B., (2012). 'Understanding the multifaceted attributes to rural poverty while assessing the water-poverty-climate change linkage in the Indian Eastern Himalaya', *International Journal Green Economics,* 6 (1), pp.73-94.

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<u>Journal Papers under Peer Review</u>

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<u>Book Chapters</u>

Mili, B., Barua, A., and **Katyaini, S**., (2015). Climate Change and Adaptation through the Lens of Capability Approach: A case study from Darjeeling, Eastern Himalaya in *Handbook of Research on Climate Change Impact on Health and Environmental Sustainability,* edited by S. Dinda

Barua, A., **Katyaini, S.**, and Mili, B., (2012). 'Reducing the Vulnerability of the Poor by Building Resilience: A Case Study from South Sikkim' Chapter 18 in *Climate change in Sikkim-Patterns, Impacts, and Initiatives,* edited by Arrawatia, M.L., and Tambe, S., 291-332.Gangtok: Information and Public Relations Department, Government of Sikkim.

Research Papers in non-refereed journals / conferences

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Conference Presentations/Training Programmes

i. Presented on 'Assessment of Virtual Water Trade Flows embedded in paddy for Sustainable Use of Water Resources in India' in European Society of Ecological Economics (ESEE) 2015 conference on 'transformations' and Summer School in University of Leeds, UK, 28 June-3 July 2015.

ii. Indo-German Centre for Sustainability (IGCS) Summer School on Sustainable Water Management in Rural Landscapes, at Department of Hydrology and Water Resources Management, Kiel University, Germany, 27 May –10 June 2015.

iii. Workshop on "Shifting Grounds: Institutional transformation, enhancing knowledge and capacity to manage groundwater security in peri-urban Ganges delta systems", organized by SaciWATERS in Kolkata 16 October 2014.

iv. E-Learning Course on "Water Footprint Assessment - Concept and Application" organized by The Water Footprint Network and University of Twente, 8-26 September 2014.

v. "Capacity Building Workshop on Systems Thinking and Adaptive Governance" organized by TERI with support from Asia-Pacific Network for Global Change Research (APN), TERI Guwahati, Assam, 28-31 January 2014.

vi. Presented on ‘Virtual Water Trade Flows - A Framework for Sustainable Use of Freshwater in North- East India’ at HSS Graduate Workshop on ‘Environment and Development: New Frontiers of Research on North-East India’ organized by Dept. of Humanities and Social Sciences, IIT Guwahati, Assam, 3 -4 January 2014.

vii. Presented on ‘Sustainable Management of Freshwater Scarcity at Sub-national Scale in India– At the interface of Science, Economy and Policy’ at Young Ecologist Talk and Interact (YETI), Nagaland University, Nagaland 16-19 December 2013.

viii. Workshop on Rural to urban transitions and the peri-urban interface: Identifying, mapping, and understanding peri-urban area in India and Pakistan, organized by East-West Center, SaciWATERs, SDPI, and Department of State, USA, Hyderabad, 30- 31 October 2013.

ix. Training program on Water Insecurity and climate Variability in India: Theoretical Understanding and Practical Programing, organized by IRAP and SaciWATERs, Hyderabad, 25 February – 1 March 2013.

x. Writeshop under the Support to Improve Climate Change Research and Information Services in South Asia (SICRISA) program of IDS, TERI, SEI and ICCAD at New Delhi, 27 - 31August 2012.

xi. Workshop on Questionnaire Design for social Sciences Research organized by the Sampling and Official Statistics Unit (SOSU), Indian Statistical Institute, Kolkata, 23-27 July 2012.

xii. Summer School in Environment and Resource Economics organized by South Asian Network for Development and Environmental Economics (SANDEE) , Bangkok, 7- 23 May 2012.

xiii. Young Social Scientist Meet organized by Omeo Kumar Das Institute of Social Change and Development under the aegis of ICSSR-NER at Guwahati, 20-21January, 2012.

xiv. Sixth Biennial Conference of the Indian Society for Ecological Economics (INSEE) on Nature, Economy and Society: Understanding the Linkages, CESS, Hyderabad 20 -22 October 2011.

ABBREVIATIONS

BCM:	Billion cubic meters
BGREI:	Bringing Green Revolution to Eastern India
CSO:	Central Statistical Organization
DGCIS:	Directorate General of Commercial Intelligence & Statistics
E-flows:	Environmental flows
EU:	European Union
EWR:	Environmental Water Requirements
GIS:	Geographical Information System
GW:	Groundwater
H-O:	Heckscher-Ohlin
IBWT:	Inter-basin water transfer
ICWE:	International Conference on Water and Environment
IELRC:	International Environmental Law Research Centre
ISOPOM:	Integrated Scheme of Oilseeds, Pulses, Oil palm and Maize
IWMI:	International Water Management Institute
LCA:	Life Cycle Assessment
MAR:	Mean Annual Runoff
MENA:	Middle East and North Africa
MoWR:	Ministry of Water Resources
NAP:	National Agriculture Policy
NAPCC:	National Action Plan on Climate Change
NCIWRD:	National Commission for Integrated Water Resource Development
NFSM:	National Food Security Mission
NGOs:	Non-governmental organizations
NMOOP:	National Mission on Oilseeds and Oil Palm
NMSA:	National Mission for Sustainable Agriculture
NRLP:	National River Linking Project

NSS:	National Sample Survey
NWP:	National Water Policy
PIM:	Participatory Irrigation Management
PRIs:	Panchayati Raj Institutions
PSI:	Potential Storage Index
RADP:	Rainfed Area Development Programme
RKVY:	Rashtriya Krishi Vikas Yojana
SWP:	State Water Policy
TERI:	The Energy and Resources Institute
TMO:	Technology Mission on Oilseeds
UNESCO:	United Nations Educational, Scientific and Cultural Organization
VW:	Virtual Water
WCED:	World Commission on Environment and Development
WF:	Water Footprint
WRM:	Water Resources Management
WS:	Water Savings
WSI:	Water Stress Indicator
WUAs:	Water Users' Associations
WUE:	Water Use Efficiency
WUGs:	Water Users Groups

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIX

Chapter 1 INTRODUCTION

1.1. SETTING THE CONTEXT OF RESEARCH

Environment, society, and economy are ***interdependent*** systems. Natural resources are essential for functioning of economy and society. However, they are incompletely accounted in the development process, which results in an imperfect relationship with nature and a distorted view of development. It leads to stress on the vital natural resources. For instance, approximately 60% of the world's ecosystem services have deteriorated due to the expansion of the global economy by 5 times since the mid of 20th century (Tietenberg 2003, Jackson 2009, Daly and Farley 2004, Daly 2003). Due to increasing realization that economy is a growing subsystem of the finite global environmental system(Rees 2003), and there is a need to ensure that environment is not degraded, the concept of sustainable development was formulated. Sustainable development is defined as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" by the World Commission on Environment and Development (WCED 1987).

Among the natural resources, freshwater is a crucial resource. "Freshwater is a finite and vulnerable resource, essential to sustain life, development, and the environment- The 4th Principle of Dublin Statement on Water and Sustainable Development, 1992 (ICWE 1992). Finiteness of the resource is reflected in the fact that it comprises merely 0.1% of total global water resources. Therefore, freshwater is considered a priority in sustainability discourse(Allan 2011, ICWE 1992).

As the economy is considered a subset of the environment, water resources are a source to as well as a sink of the economy(Rees 2003). The concern of **freshwater scarcity** emerges from water's role as a 'source' to the economy (Iyer 2003, Common and Stagl 2005, Daly and

Farley 2004, Hoekstra and Chapagain 2008). Assimilation of waste of the economy is a concern when water is considered as a sink of the economy (Common and Stagl 2005, Tietenberg 2003, Bagstad et al. 2014). Water security concept integrates water as a source to, and sink of the economy. It is developed from a holistic approach to adequately address freshwater scarcity (Schultz and Uhlenbrook 2009).

1.1.1. WATER SECURITY TO MITIGATE WATER SCARCITY

Water scarcity is a relative measure and is based on the human value judgment, unlike water deficit which is an absolute measure. Water scarcity is driven by environmental (climate change impacts), social (population growth), economic (urbanization, increasing sectoral demand) and institutional (mismanagement, government policies) factors (Amarasinghe et al. 2005, Brown and Matlock 2011, Rijsberman 2006).

Water security is crucial to mitigate water scarcity and has been defined through different disciplines perspective. One of the most relevant definitions of water security is at the interface of water resources science and policy spheres (Cook and Bakker 2012). According to it, water security encompasses sustainable use, protection of water systems, protection from water-induced hazards, sustainable development, and safeguarding of access to water functions and services for humans and environment (Schultz and Uhlenbrook 2009, Gerbens-Leenes, Hoekstra, and Van Der Meer 2008, Cook and Bakker 2012).

Sustainable use of freshwater is at a strong science-policy interface and therefore is considered crucial for achieving not only water security but also food and livelihood security. A robust water policy is formulated at the science-policy interface is crucial for inducing sustainable use of freshwater to mitigate water scarcity (Jury and Vaux 2005, Macleod, Blackstock, and Haygarth 2008).

Science-policy interface is a social process, which links scientists and other actors in the policy process and facilitates exchange, co-evolution, and joint construction of knowledge with the aim of enriching decision-making through the integration of novel scientific findings into policy-making (Hove 2007, Nursey-Bray et al. 2014). The significance of science-policy interface for enhancing sustainability is well established in the literature (Macleod, Blackstock, and Haygarth 2008). Science-policy interface is essential to develop a holistic approach as it includes scientific knowledge from both natural and social sciences. However, strengthening of science-policy interface continues to be a big challenge across the world, as science and policy are usually looked at as two independent monologs which intermittently exchange products.

A weak science-policy interface reflects a knowledge-governance gap in translating scientific knowledge into policy actions (Cash et al. 2006, Nursey-Bray et al. 2014). There is always a lag in the assimilation of scientific findings in society, which is attributed to the slow pace at which information is disseminated through various modes (Bradshaw & Borchers, 2000). Such lag leads to policy formulation which does not reflect the problems in hand and as such fails to provide solutions to the problems. Hence, there is a need to bridge knowledge-governance gap through strengthening science-policy interface which would facilitate integration of scientific knowledge, in prioritizing policy actions through knowledge transfer, dissemination and research use (Homes and Clark 2008, Wesselink et al. 2013, Ramachandran et al. 2014, Bradshaw and Borchers 2000).

A strong science-policy interface is crucial for mitigating water scarcity, particularly in emerging economies. This is because emerging economies aim for higher economic growth, which is both limited by and aggravates freshwater scarcity. Further, water scarcity does not only result from lack of physical water supply but by the cumulative effects of several other factors like poor water quality, the inefficiency of various uses and poor institutional capacity to manage water demands(Larson et al. 2009). As a result, water scarcity poses challenges for social, environmental and economic sustainability, and is an environmental governance issue. Hence, increased integration of scientific communities and policymakers is crucial to mitigate water scarcity and to ensure sustainability of the resource. Through a strong science-policy interface, policies are oriented towards providing sustainable solutions (Macleod, Blackstock, and Haygarth 2008).

1.1.2. VIRTUAL WATER FLOWS – AN EMERGING CONCEPT FOR SCIENCE-POLICY INTERFACE

Virtual Water (*hereafter* VW) flows, is an emerging concept at the science-policy interface. Allan (1993) defines VW-flows as the flow of water embedded in goods or services. Hence, it is a measure of freshwater use in production and trade (Allan 2011, Hoekstra and Mekonnen 2012). VW-flows assessment is aimed to induce sustainable use and lead to water security. VW was referred to as ‘embedded water’ till 1988 but due to its unsuccessful adoption in water research, Prof Tony Allan re-termed it as virtual water in the early 1990s. It is also called as ‘encapsulated’, ‘shadow’, ‘supposed’, ‘exogeneous’ or ‘ultraviolet’ water (Haddadin 2003, Roth and Warner 2008, Savenije 2004, Allan 2011). The appropriateness of the term is also established in the fact that it is widely being accepted as ‘virtual water trade’ by the researchers, business community, government, and policymakers.

Although the origin of VW concept is rooted in Economics, its evolution is transdisciplinary in nature with inputs from geography, environmental, economic, social, political, institutional and cultural disciplines (Antonelli and Sartori 2015, Hoekstra and Mekonnen 2012). VW concept is considered to be based on transdisciplinary discourse on Ecological Economics as it internalizes linkages between economic and ecological systems’ wellbeing (Beltrán and Velázquez 2015, Daly 2003, Lenzen et al. 2013). Further, VW-flows assessment refers to it in terms of physical flows rather than monetary flows. Therefore, VW-flows, VW-transfer or VW-movement are preferred terms over VW-trade (Hummel et al. 2006). The VW-flows concept is based on the principle of comparative advantage where water endowment is considered to be the source of comparative advantage for regions. The theoretical basis of VW- flows emerging from the notion of comparative advantage is discussed in details in chapter 2 (Allan 2011, Guan and Hubacek 2007).

The rationales of VW-flows concept are 'distribution of water scarcity' among regions with different water endowments, enhancing 'global water use efficiency' and 'net water savings'. These rationales make VW-flows concept policy relevant (Global Water Partnership 2013, Lenzen et al. 2013, Roth and Warner 2008). Further, a transdisciplinary evolution of VW-flows concept enhances the potential of VW as a helpful policy tool to determine the extent of sustainability in water use. Therefore, VW is being considered as an alternative to large engineering interventions like inter-basin water transfers (IBWT). While large engineering interventions aim to alter the water flows to meet water requirements for economic activities; VW research supports policies decisions aimed to align the economic activities with the water endowments. In South Asia, the emphasis has been on large engineering interventions for augmenting water supply, which has led to the unsustainable use of water resources. Unlike the large engineering interventions, VW flows research can induce sustainable use of water resources to mitigate water scarcity and resolve water disputes in South Asia (Bandyopadhyay and Ghosh 2009, Bandyopadhyay 2006).This is facilitated through well-informed policy decisions on the sustainable use of water resources.

1.1.3. VIRTUAL WATER RESEARCH IN SOUTH ASIA- INDIA AN INTERESTING CASE

Among South Asian countries, India is an interesting case to examine the strength of science-policy. This is because the state of India's water resources is more perilous than ever (TERI

2008). While achieving higher economic growth and development, India's water sector is facing persistent challenges of scarcity, high use, poor management and governance of water, uneven regional distribution, vulnerability to climate change, over-use and exploitation of groundwater, water use inefficiencies, water pollution, and fragmented institutional framework (UNESCO 2012, Kulkarni and Thakkar 2012).In fact, India features among the highest water users in the world. For instance, India was highest (13%) and second highest (12.2%) global water user in 1995 and 2008, respectively (Arto, Andreoni, and Rueda-Cantuche 2012). As a result, India is facing water stress and some parts of India are approaching water scarcity(Falkenmark, Lundgvist, and Widstrand 1989).

To overcome these challenges water policies have been formulated in India. They are intended to manage, distribute and regulate water resources. In addition, a need for a paradigm shift from the development of water resources towards sustainable water use is voiced in the current Five Year Plan, implemented from 2012 to 2017. This reflects a move away from a narrow engineering-construction perspective towards a more multidisciplinary understanding of water in India(Shah 2013).

In spite of these efforts, India continues to face water scarcity. For instance, National Commission for Integrated Water Resource Development (NCIWRD), Garg and Hassan (2007) and (Narasimhan 2008) estimates of total usable water resources range from 668 – 1086 billion cubic meters (BCM) (TERI 2008, Government of India 1999). Whichever estimate one accepts, there is no escaping the fact that water availability is inexorably approaching the scarcity benchmark of 1000 m^3/capita(TERI 2008). Hence, it is important to understand whether the scientific knowledge on water scarcity has been the basis of formulating the water policies in India. Secondly, it is crucial to examine whether the existing water policies are oriented towards sustainable solutions in order to mitigate water scarcity adequately. This is where VW research is relevant for India.

In the existing VW research, a need for integration of water endowments as well as water as an input in economic planning at various governance scales - global, regional, national and sub-national for sustainable water use is voiced specifically for emerging economies like India (Guan and Hubacek 2007, Lenzen and Foran 2001, Velázquez 2006).

There is a policy impetus for VW-flows research in India, firstly, through the National Water Policies' (NWPs) objective of increasing the 'water use efficiency'. It has been an objective since the first NWP (1987) (Government of India 1987, 2012d, 2002a). Secondly, through the recognition of assessing 'water footprints', and 'water savings' by the third and latest NWP(Government of India 2012d). While enhancing water use efficiency and water savings are the rationale of VW-flows concept, water footprint is a crucial component of the VW-flows conceptual framework which is discussed in detail in Chapter 2.

This research background sets the context of the present research on science-policy interface to mitigate water scarcity in India through an assessment of Virtual Water Flows. The next section identifies the research gaps which can be addressed through this research. Identification of research gaps led to the framing of research questions.

1.2. Research Gaps

There are two major research gaps in the assessment of VW-flows research of India at the science-policy interface. First research gap emanates from large differences in the estimates of VW-flows of India from the assessment at international scale (Kumar and Jain 2007, Zimmer and Renault 2003, Hoekstra and Hung 2003). India emerges as a net VW exporter according to Hoekstra and Hung (2003) (Figure 1.1), and as a net VW importer according to

Zimmer and Renault (2003) and Kumar and Jain (2007). These differences result from significantly large sub-national variations in water endowments and agro-climatic conditions in India. Even though sub-national VW-flows are crucial for mitigating water scarcity, its assessment has received little emphasis (Hoff et al. 2014). The only sub-national assessment of VW flows for India was carried out by Verma et al. (2009) for the period of 1997-2001. It considered states of Central and North-East zones of India as part of West and East zone, respectively. The assessment reveals unsustainable VW-flows from water-scarce North to water-plenty East during 1997-2001. Therefore, the differences in the estimates at the national level, and lack of recent VW-flows assessment at sub-national scale necessitate further research on sub-national VW-flows in India.

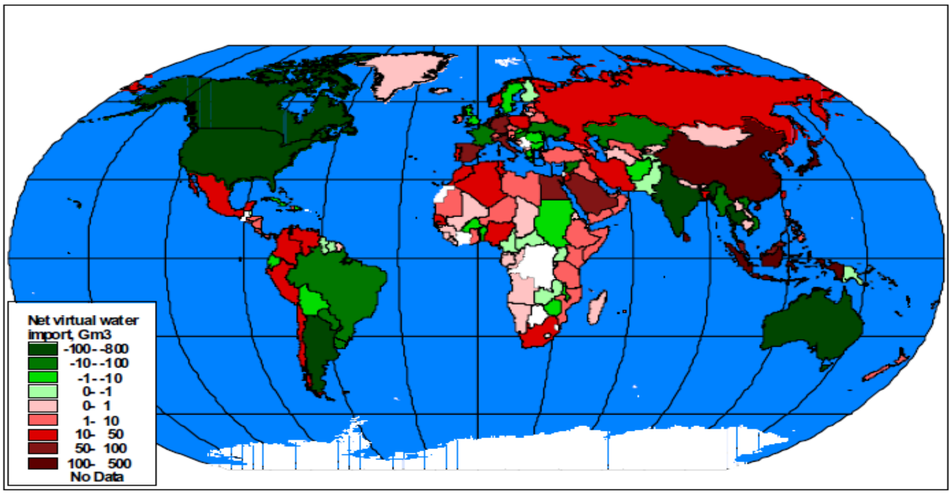

Figure 1.1: Net virtual water imports for the period 1995-1999, green represents the nations with net exports and red represent the nations with net imports
Source: Hoekstra and Hung (2003)

Second research gap exists in linking VW flows assessment with water scarcity situation at sub-national scale in order to frame meaningful policy recommendations on sustainable water use to mitigate water scarcity (Lenzen et al. 2013, Yang and Zehnder 2007, Novo, Garrido, and Varela-Ortega 2009). Kumar and Jain (2007) and Horlemann and Neubert (2007) argue that sub-national VW assessment would lead to improved policy direction on food trade and water management. Well-informed policy direction would aid in planning favorable agricultural growth and assessing ecological impacts. Mubako (2011) and Earle and Turton (2003) findings also support this argument and suggest that a national average of VW flows need to be further examined at sub-national scale to formulate judicious water policies at both sub-national and national scales.

This research aims to address these two research gaps of lack of sub-national assessment of VW-flows, and relating the VW-flows analysis with policies to mitigate water scarcity, in the existing VW literature. Research questions framed to address these research gaps are detailed out in the next section.

1.3. Research Questions

The specific research questions (RQ), aimed to be answered through this research are:

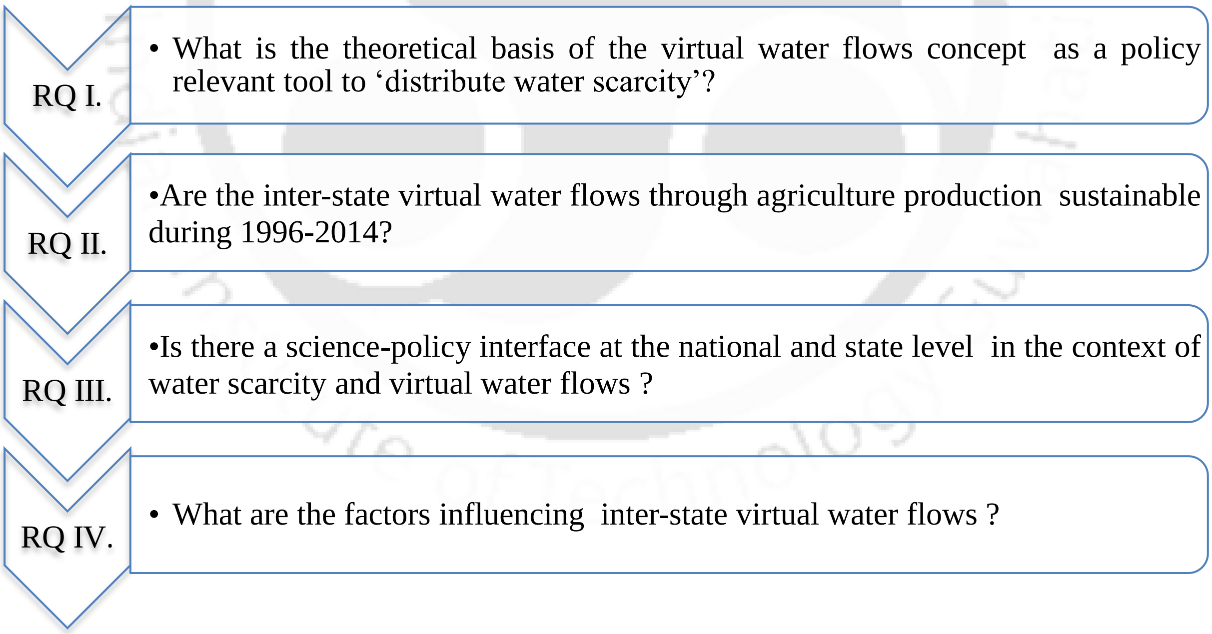

Figure 1.2: Research Questions

Therefore, the main contributions of this research or, in other words, value addition to the existing VW research are-

a) Analysis of inter-state VW-flows embedded in agriculture products to determine the quantum of WS. Sustainability of VW-flows is determined through consistency of inter-state VW-flows with the water scarcity situation in the states. While sustainable VW-flows result in WS, unsustainable VW flows result in water losses.

b) Temporal and spatial refinement in VW research in India by assessing the VW flow for the period 1996-2014. This would be an advancement to the existing sub-national VW research on India for a period of 1997-2001 carried out by Verma et al. (2009). Spatial refinement is introduced through considering states of Central and North-East zones as separate entities, which were clubbed with West and East zone, respectively in Verma et al. (2009).

c) VW-flows assessment is discussed in the context of both state and national level water policies to understand how sustainability in water use can be integrated into policy decisions (Novo, Garrido, and Varela-Ortega 2009, Yang and Zehnder 2007).

1.4. EXPECTED OUTCOMES

Based on the research questions, the two major outcomes expected from the research are -

- To provide evidence for mainstreaming water as a factor of production in policy decisions for sustainable use of water resource.
- To emphasize the importance of science-policy interface for the formulation of well-informed policies in order to address the issue of water scarcity adequately.

1.5. LAYOUT OF THE THESIS

The thesis comprises seven chapters. While first three chapters are based on extensive literature review, chapters four, five, and six are primarily based on literature review and analysis, and chapter seven concludes the research work. A brief description of each chapter is discussed here.

The **first chapter** sets the context of the research by introducing the challenges faced by the water sector in an emerging economy like India. It highlights the importance of freshwater resource in wellbeing and development. It dwells upon the concerns associated with freshwater scarcity and emphasizes the need for sustainable use of freshwater. This chapter provides the rationale for research on sustainable use of water resource in India. Further, it outlines the basic facts of water scarcity as a research issue in India and explains why water scarcity matters. The research background identifies virtual water research crucial for addressing the problem of water scarcity adequately. Based on the research background, gaps in existing virtual water literature were determined, which led to the formulation of research questions. The chapter ends with expected outcomes of the research and a brief overview of all the chapters.

The **second chapter** is the outcome of the first research question. It encompasses the conceptual and theoretical framework of virtual water flows concept. The chapter begins with the significance of virtual water flows concept. Then it presents a review of theoretical bases of virtual water flows concept, i.e., the concept is based on the notion of comparative advantage. The discussion on the theoretical framework leads to the formulation of the research hypothesis. The chapter ends with the applications and policy relevance of the concept.

The **third chapter** presents a discussion of the data and the research methodology used. It comprises three sections. The first section is on assessment of water scarcity situation in states of India. The second is on inter-state VW flows assessment. This encompasses the scope and the scale of VW-flows assessment, followed by a discussion on the data sources and collection procedure, and ends with the methodological aspects. The last section of the chapter is on examining the strength of science-policy interface in India to mitigate water scarcity.

The **fourth chapter** partially addresses the second research question by presenting the findings of water scarcity situation at the state level in India. Water scarcity situation is gauged through the indices developed through different approaches. The chapter is based on both literature review and analysis.

The **fifth chapter** is an outcome of the second and fourth research questions as it describes the results of inter-state virtual water flows assessment. The chapter begins with the quantum of water savings at the national level followed by zonal and state level.

The **sixth chapter** addresses the third and fourth research questions as it dwells upon the strength of science-policy interface to mitigate water scarcity in the state and national water policies of India. The discussion is carried out through key indicators. This discussion also highlights the relevance virtual water flows research in the context of water policies.

The **seventh chapter** concludes the research. The chapter discusses the research hypothesis framed in chapter two in the context of the VW-flows assessment. Then based on the assessments, proposes policy recommendations to strengthen the science-policy interface to mitigate water scarcity in India. The chapter ends with scoping of future research avenues.

Chapter 2 VIRTUAL WATER FLOWS

The first research question aims to explore the theoretical basis of the virtual water flows concept as a policy-relevant tool to 'distribute water scarcity'. To achieve this aim, this chapter initiates with a literature review on the conceptual framework of VW-flows. The conceptual framework is grounded in Economics; however it has evolved through a transdisciplinary approach. Due to which it is of interest to scientists, academicians, government and policymakers (Allan 2011, Ansink 2010, Hoekstra 2010). The conceptual framework comprises concepts of 'water footprint' and 'water savings'. The discussion leads to the second section, which is on the theoretical framework of VW-flows emerging from the principle of comparative advantage. International trade theories on comparative advantage have been used to understand how factor endowment and environmental resources create comparative advantage/ disadvantage for trade among two regions. The last section of the chapter is on the various applications of VW-flows conceptual and theoretical framework. The discussion on applications is organized in two sub-sections, i.e., (a) economic sectors and geographic regions, and (b) key policy areas.

This chapter is primarily based on literature review of selected crucial publications on VW-flows, which includes peer-reviewed journal papers, books, published reports of relevant government departments, academic institutions. These were collected from online repositories such as Science Direct, Elsevier, Wiley Online Library, Springer, and web portals of government departments and academic institutions.

2.1. CONCEPTUAL FRAMEWORK

The VW-flows concept is based on the understanding that economy is a subset of the environment. Therefore, it integrates both the 'water used' and 'wastewater generated' in the production process (Allan 2011). This is integrated through water footprint (*hereafter* WF), which is a measure of humanity's appropriation of fresh water in volumes of water consumed and/or polluted (Water Footprint Network 2016, Hoekstra and Hung 2003) The WF content of the good or service, consist of internal and external to the region of production. The VW-flows between regions is the WF of goods and services moving between the regions (Figure 2.1).

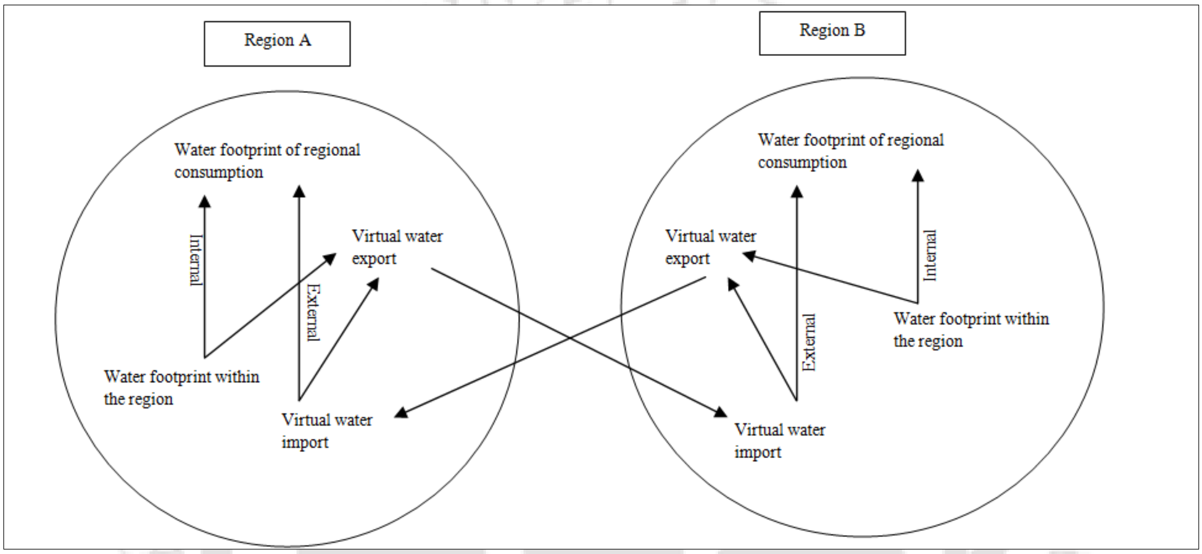

Figure 2.1: Linkage between virtual water and water footprint
Source:Hoekstra et al. (2011)

The WF content of a product comprises green, blue and grey WF. While green, and blue WF reflect environment as a source, grey WF depicts environment as a sink. Green WF measures the contribution of rainfall in the growing period of the crop under consideration. Among the economic sectors, green WF can be used only in the agriculture sector. Blue WF is the quantum of surface and groundwater consumed in irrigation, industrial use, and also in the services sector. Grey WF is the quantum of freshwater needed to assimilate wastewater, for instance, agricultural runoff consisting of nutrients and pesticides, industrial waste, and wastewater produced by the services sector. This assimilative capacity of the environment is captured through ambient water quality standards (Hoekstra et al. 2011). WF is a comprehensive measure of **water resource appropriation** as compared to the traditional measure of **water withdrawal** (Roth and Warner 2008).

Second important constituent of VW-flows conceptual framework is water savings (*hereafter* WS). WS through VW-flows is gauged from the real and theoretical virtual water. The **'real virtual water'** refers to the volume of the water used and waste water generated by a nation to produce the good or service rather than importing it. The '**theoretical virtual water'** is the potential water saved when a nation imports a good or service rather than producing it locally(Chapagain and Hoekstra 2004, El-Sadek 2011). WS refers to the difference in real virtual water, i.e., at the production and export site, and theoretical virtual water, i.e., consumption and import site (Chapagain and Hoekstra 2004). Real WS result when the movement of a good or service occurs from a region of high to low water productivity. (Hoekstra 2003). In other words, VW-flows are from relatively water abundant to water-scarce regions are considered ***sustainable***. Through these sustainable VW-flows, water scarcity can be spatially distributed. WS reflect that the economic production and trade flows of water-intensive goods are aligned with the spatial water endowments (Roth and Warner, 2008).

WS are important for the relatively water-scarce nations/regions because the water saved can be used to produce higher value agricultural crops, support environmental services preserve environmental flows, or serve growing domestic needs. This reflects how VW research can aid in prioritizing water allocation. It also helps in identifying damaged water resource hotspots, i.e., the water-scarce regions loosing water in the form of export of water-intensive crops to water-plenty regions (Allan 2011, Chapagain, Hoekstra, and Savenije 2006).

The next section explores the theoretical framework of the VW-flows concept.

2.2. THEORETICAL FRAMEWORK

The discussion on theoretical framework begins with the environmental concerns associated with trade and globalization. Then the emphasis is laid on water as a factor of production. This leads to the formulation of the research hypothesis. The section also presents a brief overview of the factors other than water that has been discussed in the literature on the theoretical framework of VW-flows concept.

2.2.1. ENVIRONMENTAL CONCERNS: TRADE AND GLOBALIZATION

While economic gains from trade have always been of research interest, a need to consider the environmental dimension of trade has recently gained momentum as there are environmental damages as well as benefits from trade (Hoekstra 2003, Wichelns 2001). At the international level, differences in environmental standards of developing and developed trading countries have been critically discussed. The developing countries usually have lower environmental standards as compared to the developed countries. They also happen to be the exporter of goods and services to the developed countries. In this trade arrangement, there could be significant environmental damages in the form of pollution, damage to ecosystem services, exploitation of natural resources and others; therefore, these environmental damages have led to developing countries being termed as ***pollution haven***[1]**.**

In contrast, there are environmental benefits of trade. Restriction on trade would mean restricting theses environmental benefits. An example of this is the 'inward-looking' domestic policies of developing countries which intended to encourage domestic production of goods and services by imposing restrictions on imports. This meant domestic production even if it was relatively more resource-intensive than the imports (Krugman and Obstfeld

[1] Pollution is a case of negative externality and require government interventions

2009).Such trade decisions restrict environmental benefits of trade and lead to damage of domestic environmental resources.

Several concerns also came with trade liberalization which aimed to integrate the global economy. The concerns were that integration may hurt the poor countries as they may need to close the budding export industries due to a mismatch in the environmental standards with the importing countries(Krugman and Obstfeld 2009). As trade influences the production and consumption processes, its expansion leads to increased production and consumption which leads to greater environmental damage. The remedial measures to curtail the environmental damage are greater efficiency, and changing the composition of the economy[2].

To assess the environmental dimension of trade several international and inter-regional trade theories have been used. Since 1960's, comparative advantage has been the most relevant principle to explain the trade and environment linkages (Xing and Kolstad 1996). The principle indicates that a nation which has a comparative advantage in the production of a good should produce and export it whereas the nation which has a comparative disadvantage should import it. It is, therefore, indicating specialization in production of goods in which a nation has the advantage to gain from trade. ***Relativity*** is at the core of the notion of comparative advantage(Ray 2011). Application of classical trade theories to environmental studies indicates that a country has a comparative advantage primarily because of two factors; first, if the country can produce a product with relatively low costs to the environment, second, if the country is relatively well endowed with natural resources (Xing and Kolstad 1996, Guan 2007). Therefore, due to the relevance of David Ricardo's theory of comparative advantage related with low cost to the environment, and Heckscher-Ohlin's theory of

[2] This is also discussed in the form of Environmental Kuznets Curve.

international trade related with factor endowment are of interest to the discussion on VW-flows.

David Ricardo's theory of comparative advantage was proposed in Principles of Political Economy in 1817. Ricardo demonstrated that the basis of trade is the **comparative cost difference** i.e. trade can take place between countries in the absence of absolute cost difference, provided there is comparative cost difference in producing the good under consideration. Trade happens based on the concept of opportunity cost. The opportunity cost of producing a good X is defined as the amount of another good Y that has to be foregone to produce an additional unit of desired good X. A country has a comparative advantage in producing a good if the opportunity cost of producing it is lower[3] in the home than in the other country. Comparative cost difference results from differences in technology used in the production of the good. In accordance with Ricardo's theory of comparative advantage, the **difference in technology** across countries gives a comparative advantage to the country with low-cost technology (Ray 2011, Xing and Kolstad 1996). In the context of environmental studies, Ricardo's theory suggests that trade occurs due to relative technological advantage. In the context of water resources management, differences in irrigation technology leads to differences in water productivity, which is 'crop yield per cubic meter of water consumption' (Cai and Rosegrant 2003). Movement of commodities from high to low water productive region would result in water savings (de Fraiture et al. 2004).

The second factor which gives a country comparative advantage is the relative endowment of natural resources, which is captured through Heckscher and Ohlin's work on factor endowment. In 1919 Eli Heckscher published "The Effect of Foreign Trade on the Distribution of Income". In 1933 Bertin Ohlin built on the work of Heckscher in "Interregional and International Trade". Heckscher (1919) and Ohlin (1933) proposed the

[3] Lower opportunity cost refers to less of good Y has to be foregone to produce additional unit of good X.

Heckscher-Ohlin model (H-O model) of international trade. H-O model emphasizes that comparative advantage need not be the outcome of only technological advantage. This is because differences in technology are ***sufficient***, but not a ***necessary*** source of comparative advantage. Even with perfectly identical technical know-how, a country will tend to export commodities which require a larger amount of factor that is relatively abundant in the country. Therefore, the **endowment of factors** of production such as land, soil of appropriate quality, water, and labor are a source of comparative advantage. The H-O model of international trade was able to explain that the differences in productivity in various countries are dependent on relative factor endowments. The trade of goods is in terms of "factor content of trade" which is equivalent to the difference between the factor content of consumption and production (Ray 2011, Reimer 2012).

The H-O model was tested by Professor Wassily Leontief (1951) and (1954) by considering labor and capital content of exports of United States (US). The US is relatively well-endowed with capital resources in comparison to labor resources relative to other countries. According to H-O model, US should have produced and exported capital-intensive products and imported labor-intensive commodities. Surprisingly, Leontief's assessment revealed just the contrary, US was exporting relatively more labor-intensive goods and importing capital-intensive goods. These paradoxical findings surprised the academia. It was later termed as the Leontief Paradox which opened up avenues for further research (Bharadwaj 1962, Stolper and Roskamp 1961) .

Numerous research studies have been carried out to understand the linkage between trade patterns and the environment based on factor endowment as a source of comparative advantage. For instance, Pethig (1976), Siebert (1977), McGuire (1982) and Brander and Taylor (1997) considered country's emission / resource management standards as the factor endowments and hence a source of comparative advantage. These research studies revealed that countries with lenient environmental policies act as the comparative advantage in producing polluting and natural resource-intensive products (quoted after Huang and Labys 2001).However, Porter and van der Linde (1995) research challenge these findings based on the argument that stringent environmental policies may not be a comparative disadvantage. Rather stringent environmental policies may act as an advantage to improve efficiency, or to develop better environmental technologies to make the economy more competitive in the world market. (e.g. Huang and Labys 2001). Therefore, it is crucial to emphasize here that environmental resources are important factors of production and hence a source of comparative advantage in accordance with the H-O model.

2.2.1.1. WATER AS A FACTOR OF PRODUCTION

Water resources are a crucial factor of production and water endowments of a nation/region act as a source of comparative advantage. VW-flows concept is derived from the notion of comparative advantage(Allan 2003). Wichelns (2001) describes "virtual water as an application of comparative advantage, with particular emphasis on water resources". Lant (2003) suggests that both VW concept and comparative advantage are applications of basic principles of economic geography. This is because both comparative advantage and VW indicate that the production of factor (water)-intensive commodities should be located close to the source of the input (water abundant region). This reflects how, VW-flows concept can be used to bring together water management practices and economic thinking (Guan and Hubacek 2007). Based on Wichelns (2001) statement, Hoekstra (2003) discussed the economic foundation of the VW flows concept in the context of international trade theory. According to the H-O model, relatively water abundant nations/ regions/states should produce and export water-intensive goods, whereas relatively water-scarce nations/ regions/states should import water-intensive goods(Hoekstra 2003).

There have been several contentions raised by Merrett (2003), Wichelns (2004), and Ansink (2010) regarding the weak theoretical basis of VW-flows concept. These contentions were later examined by Reimer (2012), who demonstrated these criticisms to be deviations from the assumption underlying the theoretical standard trade model in the real world situation, rather than weaknesses of theoretical base of VW-flows concept.

Based on this theoretical background, research hypothesis was formulated in accordance with the H-O theory of comparative advantage. The research hypothesis will be tested through assessment of inter-state VW- flows in the context of water scarcity situation.

2.2.1.1.1. RESEARCH HYPOTHESIS

The hypothesis was formulated considering ***water endowments*** as a source of comparative advantage.

Null hypothesis [H_0^1]: A relatively water-rich state, i.e. low water scarcity, ***exports*** relatively high water-intensive goods (with a high WF) and ***imports*** relatively low water-intensive goods (with a low WF).***This indicates that relatively water-rich state is a net VW-exporter.***

Alternate hypothesis [H_1^1]: A state with relatively high water scarcity, ***exports*** relatively high water-intensive goods (with a high WF) and ***imports*** relatively low water-intensive goods (with a low WF). ***The alternate hypothesis reflects that relatively highly water-scarce state is a net VW-exporter.***

Null hypothesis reflects that economic production is aligned with the water endowments and lead to the distribution of water scarcity among regions/ nations through sustainable VW-flows. While alternate hypothesis indicates that economic production is not aligned with the water endowments and there is a concentration of water scarcity in already water-scarce regions/nations. This reflects unsustainable VW-flows. The null hypothesis is in accordance with H-O model while the alternate hypothesis is in agreement with the ‘Leontief’s Paradox’.

2.2.1.2. FACTORS OTHER THAN WATER

According to the literature on the theoretical framework, there are three other sources of a comparative advantage besides differences in comparative cost, and resource endowments. These are differences in demand, economies of scale, and government policies (Suranovic 2007, Verma et al. 2009).

Linder Hypothesis states that the main driver of trade is ***demand*** for the product and explains the trade between surplus nations. The New Trade Theory proposed by Paul Krugman, Robert Solow and others, states that ***economies of scale*** and ***network effect*** are important determinants of trade. details Lastly, the existence of ***government policies*** governing the use and management of natural resources is a source of comparative advantage or disadvantage in addition to that of natural resources’ endowments(Suranovic 2007, Verma et al. 2009).

As water is of socio-political importance in India, among these three sources of comparative advantage, comparative advantage/ disadvantage created by ***water policies*** at both national and state level would be discussed in the context of mitigation of water scarcity at the science-policy interface.

VW-flows concept finds application in various economic sectors and geographical regions to address key policy issues in water resources governance and management. The next section is on the applications of VW-flows.

2.3. APPLICATION OF VIRTUAL WATER FLOWS

2.3.1. ECONOMIC SECTORS AND GEOGRAPHIC REGIONS

The agriculture sector is the largest direct water user and VW-flows embedded in agricultural commodities traces back to the initiation of farming in the Neolithic period (approximately 11000 BC) (Allan 2011). Therefore, VW-flows embedded in the agriculture sector are most explored among economic sectors. VW-flows concept was empirically tested on international food trade and movement of food grains from semi-arid and arid regions of the Middle East and North Africa (MENA)(Allan 1993, 1997, 2011). The assessment was carried out to investigate whether the trade flows are aligned with the water resources endowments (de Fraiture et al. 2004, Oki and Kanae 2004, Wichelns 2004, Kumar and Singh 2005, Hoekstra and Chapagain 2007, Wichelns 2010). Since then the global interest in VW concept has deepened and has also been extended to include the industries and services sector along with agriculture (Allan 1997, Hoekstra 2003, Guan and Hubacek 2007).

VW-flows assessment captures the ***economically invisible*** and ***politically silent*** link between water demand and water endowment at different geographical locations (El-Sadek 2010, Sadaf and Zaman 2013). The politically silent nature of VW-flows can have a light and dark side. While the light side refers to securing and saving water resources, the dark side reflects water losses due to slow and inappropriate reforms (Table 2.1). Therefore, VW-flows assessment is crucial to reveal the virtual nature of water flows and facilitate water resources governance and management at various governance levels to address global, national, sub-national and regional water scarcity(Kumar and Singh 2005).

Table 2.1: The light and the dark side of virtual water

Light side (secures, helps, saves water)	**Dark side** (hides, deludes, slows reform)
• Virtual water brings water security. • The beneficiaries are usually the rich and industrialized nations as well as other nations. • It saves the global water resources.	• Virtual nature of water being embedded in goods and services leads to hidden nature of some of the environmental and economic issues. • This hidden knowledge misleads the water managers, policy makers and politicians thereby slowing the reforms. • Virtual water trade is a silent system which makes us think that everything is progressing systematically and is a main reason for procrastinating reforms.

Source: Allan (2011)

VW concept is specifically gaining importance in some parts of the world where there is a paradigm shift from self-sufficiency in food production to food imports because of perceived water insecurity (Meissner 2003). Therefore, VW-flows have been assessed at various governance scales in parts of the ***Middle East and North Africa*** (MENA)(Allan 1997, Wheida and Verhoeven 2007, Roth and Warner 2008, El-Fadel and Maroun n.d., Wichelns 2001); ***Spain*** (Velázquez 2006, Aldaya, Matinez-Santos, and Llamas 2010, Elena and Esther 2010, Cazcarro et al. 2011); Australia (Lenzen and Foran 2001); ***China*** (Guan and Hubacek 2007, Zhang, Yang, and Shi 2011); and to some extent in ***India*** (Kumar and Jain 2007, Roth and Warner 2008, Verma et al. 2009). These VW assessments, irrespective of the geographical locations, reveal that VW-flows are not aligned with water endowments and therefore not leading to the distribution of water scarcity. For instance, relatively water-scarce North China exports water-intensive products to relatively water-rich South China. Along with aggravation of water scarcity in relatively water-scarce areas, unsustainable VW flows are also creating ‘pollution haven’ as production process generates wastewater also measured as grey WF (Guan and Hubacek 2007).

The key policy areas in which VW research finds applicability are discussed in the next section.

2.3.2. KEY POLICY AREAS

As VW-flows is an emerging concept at the science-policy interface, it is being perceived significant to bridge the communication gap between researchers, development agencies, the business community, government and policymakers (Rosegrant et al. 2002). As VW concept provides a helpful policy perspective for water-scarce areas, VW conceptual framework is being internalized in water policy discussions. For instance, Ministry for the Environment, Government of Spain enacted a regulation to use WF as a tool for implementation of River Basin Management Plans in accordance with EU Water Framework Directive (Garrido et al. 2010).

VW-flows assessment supports policy decisions on prioritizing WS strategies, such as production of those goods which are most suited to local environmental as well as socio-economic conditions; identifying and reducing unsustainably high VW-flows, and coordination between VW importers and exporters(Wichelns 2010, Zhang, Yang, and Shi 2011, Zhao, Chen, and Yang 2009). Therefore, it finds application in resolving various issues related to food security, economic diversification, efficient use, conflict mitigation, and water scarcity management (Wichelns 2003, Yang and Zehnder 2007).

- **Water availability and food security**: Based on VW research, water-scarce nations have an opportunity to make well-informed decisions on importing water-intensive food products to achieve food security rather than allocating their scarce water resources to food production to meet the entire food demand (Wichelns 2003, Hoekstra and Hung 2003, de Fraiture et al. 2004). Some of the major concerns associated with imports of food to achieve food security are of food dependency on other nations, loss of livelihood of agriculture workers of the food importing nations. For instance, subsidies provided to farmers in EU and the US have increased the virtual water exports from the EU and USA to the Nile countries. The virtual water imports of Egypt and Sudan has aggravated the impacts of drought on farm employment and poverty (Allan 2011).

- **Water use efficiency and economic diversification**: VW research supports decisions on allocation of scarce water resources to production and marketing activities which have higher returns(Wichelns 2003, 2001). It aids in strategizing economic diversification which is important for strengthening the economy(Allan 1997). Diversifying the economy is a way of reducing the stress on water resources as agriculture is the largest water consumer as compared to other economic sectors. With economic diversification and competing claims over water, water use efficiency increases. Economic diversification in the context of water is voiced in 'More jobs per drop' campaign in developing and undiversified economies (Allan 2011). Highly developed and water-rich countries, like Norway, and Switzerland are net VW importers because they have a comparative advantage in the production of non-water intensive products. In contrast, undiversified and water-scarce nations, Afghanistan and Malawi are net VW exporters. With the knowledge created through VW research, such water-scarce undiversified economies can plan economic diversification and sustainable use of scarce water resources. Further, VW concept is useful in generating ***public awareness*** of the water requirements of production and consumption process. The use of tools like VW and WF can indicate how to allocate and use water in a more sustainable and judicious manner. This knowledge creation would reduce the anthropogenic pressure on water resources and encourage sustainable production and consumption (Wichelns 2003, Elena and Esther, 2010).

- **Conflict mitigation and water scarcity management:** The knowledge created from VW- flows could be useful in conflict resolution on shared water resources. Realizing the 'limits to growth' and sustainable management of water for conflict resolution is an important application of VW and WF. It is essential to constrain the internal and external WF to reduce the global and regional water use in order to avoid shifting the pressure (of overexploitation and inefficient water management) to other nations or regions. Inappropriate water scarcity management leads to ***environment degradation***, for instance, the developing countries exports are usually dominated by water resource-intensive agriculture goods and the exports of the developing country might increase pressure on its water resource base due to the high demand from the importing country. This has been observed in Thailand, India, and Spain where the detrimental impacts are seen on the groundwater reserves as a result of exports(Van Hofwegen 2003). The VW assessment is necessary as it highlights these unsustainable patterns and helps in making appropriate water scarcity management strategies.

In this chapter, the theoretical basis of the VW-flows concept as a policy-relevant tool to 'distribute water scarcity' was discussed. The subsequent chapter deals with the data and methodology used for assessment of water scarcity situation, VW-flows, and the science-policy interface.

Chapter 3 DATA AND RESEARCH METHODOLOGY[4]

The research involves carrying out three assessments to achieve the research objectives. The *first* is establishing water scarcity situation at the state level for which both qualitative and quantitative data were collected. The *second* is an assessment of inter-state VW-flows, which is based on quantitative data. The *third* assessment involves a critical review of water policies in the context of inter-state VW-flows assessment to gauge the strength of science-policy interface to mitigate water scarcity. For the third part, in addition to the findings of the first and second parts of assessment, qualitative data was collected. While the first two assessments correspond to research question II. The third assessment is related to research questions III and IV and uses the outcomes of the first two assessments. The sources from which data was collected and research method used for the three assessments are discussed in this chapter.

3.1. WATER SCARCITY SITUATION

This section comprises a description of the data collection procedure and research method used for establishing the water scarcity situation.

3.1.1. DATA COLLECTION PROCEDURE

To establish the water scarcity situation at the state level in India, a systematic literature review was carried out. The literature reviewed was on existing scientific approaches/indices on assessing sub-national water scarcity in India. This is because ‘plural normative views’ exist on water use, access, and value and a multidimensional view is crucial to assess water

[4] Section 3.1 and 3.3 of this chapter have been published in Water Policy journal in 2016 entitled ‘*Water Policy at science-policy interface - challenges and opportunities for India*’. Sections 3.2 of this chapter has been submitted to Water Resources Research journal in 2016, entitled *‘Assessment of Regional Virtual Water Flows in India (1996-2014)*’ (To be revised and resubmitted).

scarcity. There are only a few studies which have explored water scarcity through the multidimensional view of water scarcity, i.e., through the inclusion of technical, ecological, and socio-economic dimensions (Hamlin 2000, Feitelson 2012, Jaeger et al. 2013, Larson et al. 2009, Mehta 2011).

Although water was considered in almost all environmental and developmental indices such as the human development index, and environmental sustainability index, there was no exclusive index on water till the 1960s. The first water indices were 'water quality index' by Horton (1965) and Falkenmark Water Stress Indicator (1989)(Crabtree, Cluckie, and Forster 1987, Esty and Porter 2005, Sullivan and Meigh 2003). Since then, water scarcity measures have evolved from an anthropocentric to an eco-centric approach.

In water scarcity assessment, Brown and Matlock's (2011) contribution was to classify the existing water scarcity indices into approaches based on the common criteria of assessment. These approaches are human water requirements; water resources vulnerability; environmental water requirements; and water footprint (WF) and life cycle assessment (LCA). These approaches reflect a transition from anthropocentric to eco-centric approach (discussed in details in Chapter 4). As Brown and Matlock (2011) classification of indices is based on an extensive review of methodologies of the indices, it was considered suitable for this research.

In addition to the indices classified by Brown and Matlock (2011), other relevant indices were also considered. For instance India Water Stress Index (WSI) also known as Potential Storage Index developed by Columbia Water Centre (2011) and Drought Index developed by (Government of India 2014c). These indices were added to the water resources vulnerability approach (II) because they reflect water scarcity based on the vulnerability of water resource (Figure 3.1, these two indices are marked by *).

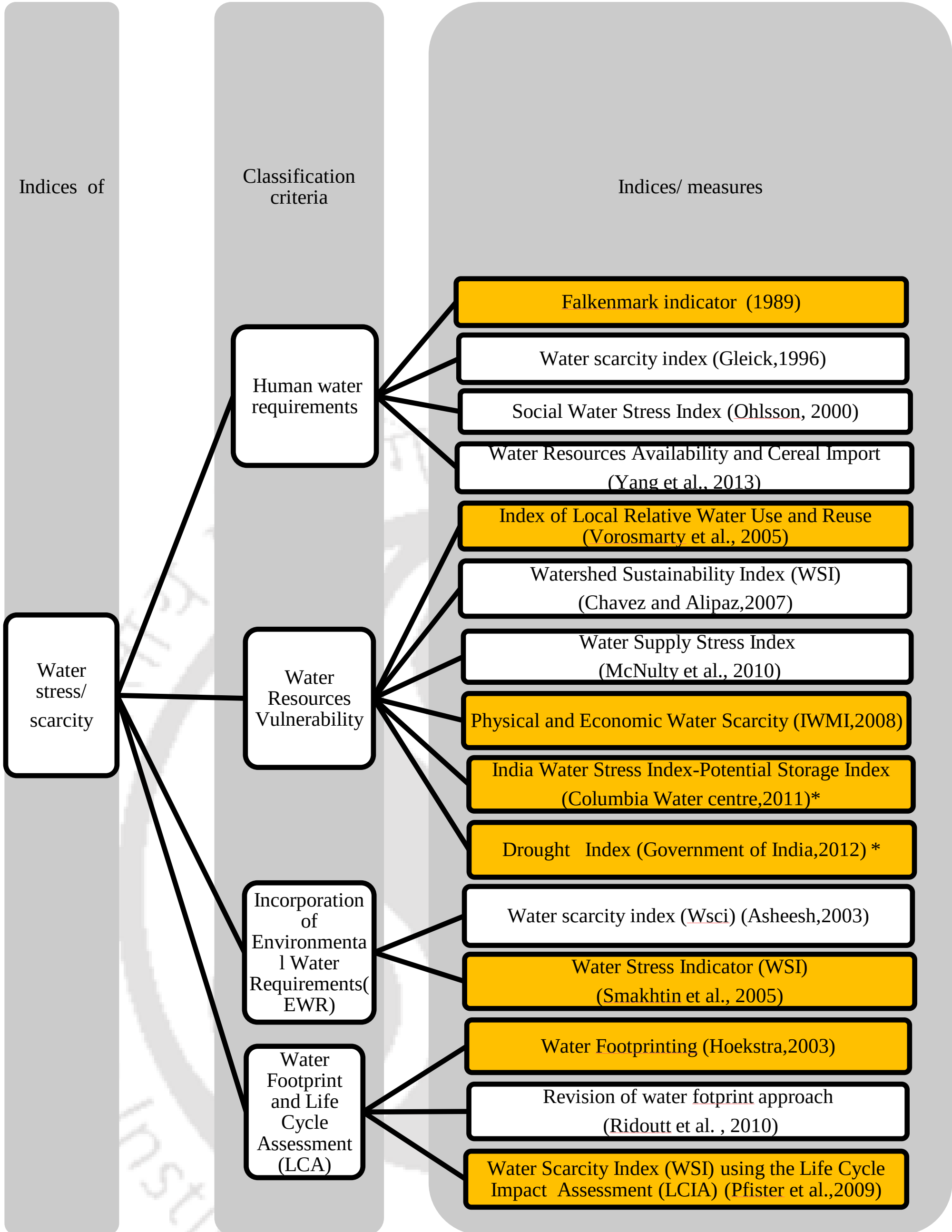

Figure 3.1: Various approaches to assess water scarcity

3.1.2. Research Method

To determine the water scarcity of states, the range of each index was categorized into four levels, i.e., (1) low to moderate, (2) moderate, (3) moderate to high, and (4) high (Table 3.1). Using this categorization, states were classified into water scarcity level of 1 to 4 according to each of the indices. Subsequently, water scarcity levels of a state indicated by indices emerging from the same approach were aggregated through arithmetic mean. This was followed by aggregating water scarcity levels of a state according to all the four approaches using arithmetic mean. Lastly, the water scarcity of states established through this method was mapped using geographical information system (GIS).

Table 3.1: Water Scarcity Approaches/Indices used to assess water scarcity situation in India

Approach	**I: Human water requirements**	**II: Water resources vulnerability**				**III: Incorporation of water requirements of environment**	**IV: Water footprint and life cycle assessment**	
Indices	Falkenmark index (Falkenmark, Lundgvist, and Widstrand 1989)	Index of Local Relative Water Use and Reuse (Vorosmarty et al. 2005)	Physical and Economic water Scarcity (IWMI 2008a)	India Water Stress Index (Normalized Deficit Index Multiyear max) (Columbia Water Centre 2011)*	Drought Index (Government of India 2014c)*	EWR Water Stress Indicator (Smakhtin, Revanga, and Doll 2005)	Water Footprint (months) (Hoekstra et al. 2012)	LCIA (m^3/m^3) (Pfister, Koehler, and Hellweg 2009)
Low-moderate (1)	I>1700 m3/capita/yr: No water stress	<0.4	Little or no	I<5.0	1: 1 in 15 means once in 15 years and 2: 1 in 5 means once in 5 years	<0.5	0-1	I<0.1 to 0.5
Moderate (2)	1000<I<1700 m^3/capita/yr: Water stress	0.4-0.6	Economic	5.1-10	3:1 in 4 means once in 4 years	0.5-0.7	2-5	0.5-0.7
Moderate-High (3)	500<I<1000 m^3/capita/yr: Water scarcity	0.6-0.8	Approaching physical	11-100	4: 1 in 3 means once in 3 years	0.7-1	6-9	0.7-0.9
High (4)	I < 500 m^3/capita/yr: Absolute scarcity	0.8-1	Physical	I>100	5: 2 in 5 means twice in 5 years	≥1	10-12	I>0.9

*Added by the authors

3.2. Virtual Water Flows

This section is organized in three sub-sections. The first is on scope and scale of VW-flows assessment. The second sub-section deals with the data collection procedure. The last sub-section is on the research method used for the assessment.

3.2.1. Scope and Scale

Among the economic sectors, the agriculture sector has been identified for the assessment of VW-flows as it is the largest direct water user (Hoekstra et al. 2011). Scoping of the study involved identifying the agriculture goods for the assessment. The discussion on scale revolves around the selection of an appropriate sub-national scale for assessment. It also dwells upon the significance of time period of the assessment for understanding the extent of science-policy interface for mitigation of water scarcity.

3.2.1.1. Scope: Agriculture Sector

Agriculture sector uses approximately 65-70% of freshwater resources. In fact, in some states agricultural water use is as high as 90% (Parihar and Idnani 2012, IARI 2010). High water use in agriculture is attributed to low water use efficiency (WUE). It is merely 30% in India (Antonelli and Sartori 2015). Further, agriculture is the primary source of livelihood for nearly 70% of the population in India as it employs the largest share of main workers (Singh 2014). For instance, around 76% in 1999-2000, 73% in 2004-05, and 68% in 2009-2010 (Government of India 2011b, c). Therefore, with many regions in India facing water scarcity, there is a concern over sustainable water use in agriculture for food and livelihood security, in addition to, water security (Schultz and Uhlenbrook 2009, Allan 2011).

India has the largest extent of rainfed agriculture in the world, i.e., about 67% of net sown area, reflecting a significant contribution of green WF[5] to agriculture production (Sharma et al. 2006, Government of India 2012e, Venkateswarlu 2011). Agriculture is a climate-sensitive sector; dry zones are predicted to become drier, while wet zones are predicted to become wetter in India. With these changes, the productivity of rainfed agriculture is a huge concern for food security (Chauhan et al. 2014, Sivakumar and Stefanski 2011). Remaining 33% is irrigated agriculture, i.e., blue WF[6]. Irrigation in India is predominantly through groundwater, i.e., 60%. In fact, India is the largest groundwater user in the world because of low WUE and unsustainably high rate of abstraction (The World Bank 2015, Amarasinghe and Xenarios 2009). Further, several mega infrastructure projects, such as National River Linking Project (NRLP), are being pursued to enhance irrigation water supply. However, these projects are being heavily criticized for inadequate assessment of socio-ecological sustainability(IWMI 2008b).

Another challenge for the agriculture sector in India is the wastewater generation due to fertilizer and pesticide application; this is reflected in grey WF[7]. Usage of fertilizers and pesticides was intensified during Green Revolution, a public intervention by Government of India in the 1960s. Green Revolution was intended to prevent famine and achieve self-sufficiency in food grains production. However, the intervention did not adequately consider the optimal usage of fertilizers. Excessive usage of fertilizers has led to wastewater generation as run off. (Kumar, Gulati, and Cummings 2007, The World Bank 2012, Government of India 2008b, Yedla and Peddi 2003).

Since Green Revolution, Government of India has taken several initiatives to improve the land productivity of food grains, and oilseeds. These are Rashtriya Krishi Vikas Yojana

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[5] Green WF- discussed in section 2.1

[6] Blue WF- discussed in section 2.1

[7] Grey WF- discussed in section 2.1

(RKVY), National Food Security Mission (NFSM), National Mission on Oilseeds and Oil Palm (NMOOP), Integrated Scheme of Oilseeds, Pulses, Oil palm and Maize (ISOPOM), Bringing Green Revolution in Eastern India (BGREI), National Mission for Sustainable Agriculture (NMSA). In addition to these, State governments have also introduced several interventions (Government of India 2015c). Enhancing land productivity through these interventions has been prioritized because land is considered as a crucial factor of production in agriculture. In contrast, water concerns have always been embedded in agriculture concerns and very few exclusive interventions have been made to enhance water productivity. For instance, for the first time in economic planning, water was considered as one of the focal themes in the Eleventh Five Year Plan (2007-2012). In previous Five Year Plans water was not considered separately but as a component of agriculture. Hence water has been exploited for agriculture growth (Government of India 2007b, 2002b).

India is a major producer of food grains and oilseeds (Swaminathan and Bhavani 2013). Therefore, these two categories of agriculture goods were selected for assessment of VW-flows.

3.2.1.1.1. FOOD GRAINS

Food grains form the largest share of agriculture produce in India and are at the core of India's food security agenda according to The National Food Security Act, 2013; National Policy for farmers, 2007; and first National Agriculture Policy (NAP), 2000 of India (FAO 1995, Government of India 2000, 2010, 2007c, 2013a, Sivanappan 1984). As an outcome of Green Revolution, India has the largest area under production and highest quantity produced of wheat and rice in the world. In addition to rice and wheat, maize, pulses, and millets are major food grains produced (Table 3.2). It is important to emphasize here that approximately

66% of the food grains production is through irrigated agriculture and remaining 44% is contributed by rainfed agriculture (Venkateswarlu 2011).

While considering the Central Government interventions for enhancing food grain production, National Food Security Mission (NFSM) is one of the most prominent schemes, which came into existence in October 2007. It was intended to enhance production of rice, wheat and pulses to achieve food security during the Eleventh Five Year Plan. NFSM has been expanded to cover coarse cereals and commercial crops along with rice, wheat and pulses in the Twelfth Five Year Plan. Here, coarse cereals refer to maize, sorghum, barley, and millets (Government of India 2016b).

In addition to NFSM, Bringing Green Revolution to Eastern India (BGREI) was introduced as a part of *Rashtriya Krishi Vikas Yojana* (*RKVY*) in 2010-11 (Government of India 2016a). BGREI was introduced to meet the growing food requirement and reduce the over-exploitation of natural resources like water and soil in the states of North-West region (Government of India 2012a). BGREI was intended to enhance the land productivity of 'rice based cropping systems'(Government of India 2012a). It focuses on Assam from North-Eastern zone; Bihar, Jharkhand, Orissa, and West Bengal from Eastern zone; Chhattisgarh from the Central zone; and Eastern Uttar Pradesh from Northern zone.

Based on systematic review of literature and government publications, primarily those of Ministry of Agriculture, seven categories of food grains were identified for the assessment. These are rice, wheat, sorghum and millet, maize and millet, gram, pulses other than gram, and other sorts of grains (barley) (Table 3.2). From hereafter, discussion on food grains encompasses these seven categories only. States which are major producers of these food grains range from Haryana, Punjab, Uttar Pradesh in North; Bihar in East; Madhya Pradesh in

Central; Gujarat, Maharashtra, and Rajasthan in West; to Andhra Pradesh, Karnataka and Tamil Nadu in South (Table 3.2).

Table 3.2: Major food grains producing states zone-wise

Food grains	**Major food grains producing states zone-wise**					
	North	**North-East**	**East**	**Central**	**West**	**South**
Rice	Haryana, Punjab, Uttar Pradesh	Assam	Bihar, Orissa, West Bengal	Chhattisgarh		Andhra Pradesh, Karnataka, Tamil Nadu
Wheat	Haryana, Punjab, Uttar Pradesh, Uttaranchal		Bihar, West Bengal	Madhya Pradesh	Gujarat, Maharashtra, Rajasthan	
Jowar Bajra	Haryana, Jammu & Kashmir, Uttar Pradesh			Chhattisgarh, Madhya Pradesh	Gujarat, Maharashtra, Rajasthan	Andhra Pradesh, Karnataka, Tamil Nadu
Maize & millet	Himachal Pradesh, Uttar Pradesh, Uttaranchal	Arunachal Pradesh	Bihar, Jharkhand	Chhattisgarh, Madhya Pradesh	Gujarat, Maharashtra, Rajasthan	Andhra Pradesh, Karnataka, Tamil Nadu
Gram	Haryana, Uttar Pradesh		Bihar, Jharkhand	Chhattisgarh, Madhya Pradesh	Gujarat, Maharashtra, Rajasthan	Andhra Pradesh, Karnataka
Pulses other than gram	Uttar Pradesh		Bihar, Jharkhand, Orissa	Chhattisgarh, Madhya Pradesh	Gujarat, Maharashtra, Rajasthan	Andhra Pradesh, Karnataka, Tamil Nadu
Other sorts of grains (Barley)	Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Uttar Pradesh, Uttaranchal		Bihar, Jharkhand, West Bengal	Chhattisgarh, Madhya Pradesh	Rajasthan	Tamil Nadu

Source: Compiled from Government of India (2015a)

The second category of agriculture product identified for VW-flows assessment is oilseeds. In the subsequent sub-section significance of considering oilseeds in the VW-flows assessment is discussed.

3.2.1.1.2. OILSEEDS

India is the largest producer of oilseeds in the world as it accounts 12-15% of the global area under oilseed production (Jha et al. 2012). Oilseeds are the second largest produced agriculture product after food grains in India. In addition, the economic value of oilseed production is high and second only to food grains. There are nine major oilseeds cultivated in India. Among these groundnut, rapeseed & mustard, soybean, sunflower, sesamum, safflower, and niger are edible oilseeds; and castor and linseed are the non-edible oilseeds. Approximately 87% of oilseeds produced in India are groundnut, rapeseed-mustard and soybean (during 2010-2011)(Government of India 2012a).

To increase the production and productivity of oilseeds Technology Mission on Oilseeds (TMO) was introduced in May 1986. In the 1990s, pulses, oil palm and maize were added to the Technology Mission, hence, it is known as Integrated Scheme of Oilseeds, Pulses, Oilpalm and Maize (ISOPOM) since 2004(Government of India 2012a). With the expansion and crop intensification, production of oilseeds has tripled from 9Mt in 1980-1981 to 28 Mt in 2008-09 with 3.53% as the annual growth rate(Jha et al. 2012). However, the yields of oilseeds in India are extremely low in comparison to other nations of the world. In order to enhance the growth in oilseeds production, social, economic and environmental sustainability of agriculture through the delivery of technology and services and strengthening of institutions is considered important(Jha et al. 2012). BGREI scheme is likely to financially support the production of oilseeds in the eastern region of India (Ghosal 2015).

Oilseeds production is concentrated in Central, Western, and Southern zones of India. Primarily in Madhya Pradesh state from Central, Gujarat and Rajasthan states from Western, and Andhra Pradesh and Karnataka states from Southern zones (Table 3.3). These are known as high-risk zones because of uncertain returns on investments(Jha et al. 2012).

Table 3.3: Major oilseeds producing states zone-wise

Oilseeds/ oils	Major oilseeds producing states zone-wise					
	North	**North-East**	**East**	**Central**	**West**	**South**
Oilseeds cotton	Punjab, Haryana			Madhya Pradesh	Rajasthan, Gujarat, Maharashtra	Andhra Pradesh, Karnataka, Tamil Nadu
Oilseeds other than cotton (soyabean, groundnut, rape and mustard)		Soyabean production since ancient times		Madhya Pradesh, Chhattisgarh	Maharashtra, Rajasthan, Gujarat	Andhra Pradesh, Karnataka, Tamil Nadu
Ground nut oil					Gujarat, Maharashtra, Rajasthan	Andhra Pradesh, Karnataka, Tamil Nadu
Mustard oil	Haryana, Uttar Pradesh	Assam	West Bengal	Madhya Pradesh	Rajasthan, Gujarat	
Castor oil			Orissa		Rajasthan, Gujarat	Andhra Pradesh, Karnataka, Tamil Nadu
Other veg oil (soyabean, sunflower, sesame)	Haryana, Punjab, Uttar Pradesh	Assam	Orissa, West Bengal	Madhya Pradesh, Chhattisgarh	Gujarat, Maharashtra, Rajasthan	Andhra Pradesh, Karnataka, Tamil Nadu
Oil cakes (soyabean, groundnut, rape and mustard)		Soya bean production since ancient times		Madhya Pradesh, Chhattisgarh	Maharashtra, Rajasthan, Gujarat	Andhra Pradesh, Karnataka, Tamil Nadu

Source: Compiled from Government of India (2015a)

The next section is on the spatial and temporal scales at which research is carried out.

3.2.1.2. Scale

3.2.1.2.1. Spatial Scale

The state was identified as a suitable sub-national scale for VW-flows assessment as there are significant variations in water endowments and agro-climatic conditions at the state level in India. Water and agriculture are both state subjects according to the Constitution of

India(Government of India 2014b). Hence, sub-national water policies, as well as, agriculture schemes and programs are implemented at state level. Therefore, inter-state VW-flows assessment would be crucial for supporting well-informed state policies and programs on water management, planning favourable agricultural growth considering the ecological constraints, and food trade (Kumar and Jain 2007, Horlemann and Neubert 2007, Mubako 2011, Earle and Turton 2003).

3.2.1.2.2. TEMPORAL SCALE

Planned development in India's economy initiated in 1950-51 and agriculture sector was identified as the key economic sector for development and eradication of poverty (Chand and Parappurathu 2012). Six decades of agriculture growth, i.e. from the 1950s to 2010/11 were classified into five phases by Chand and Parappurathu (2012) based on the criterion of decadal trend growth rate[8].

Among the five phases, the last two phases, i.e., *post-reforms period (1996-2005),* the *period of recovery (2005-2011) up to 2014* are crucial for understanding the sustainability of inter-state VW-flows. This is because the period of 1996-2014 represents the period of transformation in water policy of India towards sustainability and water security, in addition to, recovery in agriculture growth after the reforms. The transformation can be inferred from the paradigm shift from water development to water management (Shah 2013).

Post- reforms period (1996-2005) for agriculture sector of India is characterized by the shift in focus and resources away from agriculture sector to other economic sectors. This shift in

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[8] Decadal trend growth rate: The GDP-Agriculture series was smoothened by considering 2-year moving averages. This eliminates the influence of abrupt weather variations and other shocks. Subsequently, semi-log trend was fit with the smoothened data to estimate the trend growth rates. Decadal trend growth rate was determined by taking the decade-wise series from 1950-51 to 2010-11. Five distinct growth phases were determined from plotting the growth trends. This method of identifying structural breaks was preferred over cumbersome assessment of year-on year GDP growth of six decades.

focus led to decrease in public and private investment in agriculture, resulting in stagnation of area under irrigation, a decrease in the use of fertilizers, and a decline in the provision of electricity for agriculture(Chand and Parappurathu 2012).

In the period of recovery (2005-2011) several important reforms were made. Most significant reforms made for sustainable agricultural water use are decentralized decision making; renewed focus on rainfed agriculture; emphasis on technology; and sustainable and efficient groundwater use (Government of India 2006c). To illustrate, NAP (2000) and Twelfth Five Year Plan (2007-2012) emphasize on reforms and management of agriculture both at the state and national level for decentralized decision-making and effective implementation(Government of India 2008a, 2010). National Food Security Act, 2013 encourages decentralized decision-making by considering monitoring and evaluation of food security programmes as state governments' responsibility(Government of India 2013a). For renewed focus on rainfed agriculture, National Rainfed Area Authority was established in 2007 and Rainfed Area Development Programme (RADP) was implemented in 22 states during 2012-2013. RADP is designed as an 'end to end approach'(Government of India 2014a). It was crucial because rainfed agriculture comprises 67% of arable land and contributes 44% of food grains. Among the food grains, pulses, and maize and millets are the most prominent in rainfed dry lands. During this period, a technology mission was introduced to enhance their productivity (Government of India 2006b, 2013b). Hence, both post-reforms period and period of recovery are important for understanding the sustainability of inter-state VW-flows. Next section is on data collection procedure for the assessment.

3.2.2.Data Collection Procedure

There were three parameters on which data was collected for assessing the inter-state VW-flows. These are the inter-state movement of food grains and oilseeds; WF of the selected food grains and oilseeds; and their yields. Quantitative data on the inter-state movement of food grains and oilseeds was collected from Directorate General of Commercial Intelligence & Statistics (DGCIS); WF from Mekonnen and Hoekstra (2010) and Mekonnen and Hoekstra (2011); and yields was collected from publications of Ministry of Agriculture. While the data on the inter-state movement of food grains and oilseeds data are available on an annual basis for the period of 1996-2014, WF data is available as an average of the post-reforms period, i.e., 1996-2005. Data on the yield of food grains and oilseeds was collected to estimate the WF for the period of 2005-2014.

Data on inter-state movement of food grains and oilseeds was collected through the visit to the DGCIS, Kolkata, and Government Publications office in Delhi. Yield and WF data were collected from the online repository. Prior to using WF estimates of Mekonnen and Hoekstra (2010), and calculating WF for the period of 2005-2014 based on WF of 1996-2005, an e-learning course on WF produced by the World Bank Institute in collaboration with University of Twente, and International Water Footprint Network, was undertaken. In addition, the state level WF of food grains and oilseeds for India was discussed with Dr M. M. Mekonnen prior to carrying out the WF and VW-flows assessment. Table 3.4 and Table 3.5 describe the categories of food grains and oilseeds on which data was collected. It is important to emphasize here that to collect comprehensive data from these sources first the names of the category were matched. For instance, 'rice in the husk' category of inter-state movement is comparable to 'rice in the husk (paddy or rough)' category on which WF data is available. Matching the categories was important because WF varies in every step of the process.

Table 3.4: Data sources for assessment of inter-state VW-flows embedded in food grains

Parameter		Inter-state movement of food grains	WF of food grains	Yield
Description		Inter- State Movements/ Flows of Goods by Rail, River and Air for Twelve Months Ending March	Green, Blue and Grey WF, Total WF is referred to as VW.	Yield to estimate WF of 2005-2014 from 1996-2005
Time period		1996-2014 (annual)	1996-2005 (average)	1996-2014 (annual) Estimated average for two periods 1996-2005 and 2005-2014
Categories of food grains for which data was collected	Rice	Rice in the husk	Rice in the husk (paddy or rough)	Rice
		Rice not in the husk	Rice, husked (brown)	
	Wheat	Wheat	Wheat (Durum wheat, Wheat nes and meslin)	Wheat
		Wheat flour	Wheat or meslin flour	
	Gram	Gram and gram products	Chickpeas, dried, shelled, whether or not skinned or split	Gram
	Pulses other than gram	Pulses other than gram	Urd,mung,black/green gram beans drid shelld,whether/not skinnd/split	Pulses
	Jowar and bajra	Jowar and bajra	Sorghum and Millet	Jowar and bajra
	Maize and millets	Maize and millet	Maize and Millet	Maize and millet
	Other sorts of grains	Other sorts of grains	Millets and barley	Small millets (ragi)
Data Source/ Organizations		DGCIS, Ministry of Commerce and Industry, Govt. of India Kolkata (annual publications from 1996-2014)	Mekonnen and Hoekstra (2010) and (2011)	Ministry of Agriculture (annual publications from 1996-2014)

Table 3.5: Data sources for assessment of inter-state VW-flows embedded in oilseeds

Parameter		**Inter-state movement of oilseeds**	**WF of oilseeds**	**Yield**
Description		Inter- State Movements/ Flows of Goods by Rail, River and Air for Twelve Months Ending March	Green, Blue and Grey WF, Total WF is referred to as VW.	Yield to estimate WF of 2005-2014 from 1996-2005
Time period		1996-2014 (annual)	1996-2005 (average)	1996-2014 (annual) Estimated average for two periods 1996-2005 and 2005-2014
Categories of food grains for which data was collected	Oilseeds cotton	Oilseeds cotton	Cotton-seed oil	Cotton (Cotton Advisory Board)
	Oilseeds other than cotton	Oilseeds other than cotton	Oilseeds	Soyabean, Groundnut, rape and mustard
	Ground nut oil	Ground nut oil	Ground nut oil	Groundnut
	Mustard oil	Mustard oil	Rape,colza and mustard oil	Rape and mustard
	Castor oil	Castor oil	Castor oil	Castor
	Other veg oil	Other veg oil	Soya-bean oil; Sunflower-seed/safflower oil; Sesame oil	Soya-bean oil; Sunflower-ed/safflower oil; Sesame oil
	Oil cakes	Oil cakes	oil cakes	Soyabean, Groundnut, rape and mustard
Data Source/ Organizations		DGCIS, Ministry of Commerce and Industry, Govt. of India Kolkata (annual publications from 1996-2014)	Mekonnen and Hoekstra (2010) and (2011)	Ministry of Agriculture (annual publications from 1996-2014)

3.2.3. RESEARCH METHOD

For the inter-state VW-flows assessment, WF for the period of recovery up to 2014 (2005-2014) was estimated based on WF of the post-reforms period (1996-2005) by using Equation 1. This equation is used to estimate WF on the basis of the assumption that WF is a function of yield (Duarte, Pinilla, and Serrano 2014, Mekonnen and Hoekstra 2011). The yield of a crop depends on climate (precipitation and reference evapo-transpiration) and agriculture technology (Duarte, Pinilla, and Serrano 2014, El-Sadek 2011, Government of India 2014a). Recalculating WF coefficients for 2005-14 based on 1996-2005 was considered crucial because yield has remained constant within each period but varies between the two periods(Duarte, Pinilla, and Serrano 2014, El-Sadek 2011, Government of India 2014a).

$$WF_{2005-2014} = WF_{1996-2005} * \left(\frac{Yield_{1996-2005}}{Yield_{2005-2014}} \right)$$

Equation 1

(Mekonnen and Hoekstra 2011, Duarte, Pinilla, and Serrano 2014)

Among several methodological approaches to quantify VW-flows, WF based approach was identified as suitable because it is considered as a *classical approach*, and is most widely used. The classical approach has evolved from Hoekstra and Hung (2003) and can be contextualized at various governance scales considering the data requirements (Lenzen et al. 2013). Method from Chapagain, Hoekstra, and Savenije (2006) was used to assess the water savings resulting from inter-state VW-flows in India. It was considered suitable over that of environmentally-extended input-output analysis primarily because of three reasons. Firstly, the focus of research is only on the largest water-using sector of the economy, i.e., agriculture, similar to that of Chapagain, Hoekstra, and Savenije (2006). Environmentally-extended input-output methodology is appropriate for assessing VW-flows of all three economic sectors to establish the extent of their interdependence (Guan and Hubacek 2007). Second, input-output tables are prepared at the national level periodically, i.e., at a gap of five years since 1968-1969 by the Central statistical Organization (CSO) in India (Munjal 2007).Very few state-level input-output tables have been developed for particular years by research institutes (Sinha 2009).These input-output tables are not adequate frameworks for assessing the sustainability of inter-state VW-flows during 1996-2014. Third, methodological research on WF of industries and services sector is still at a nascent stage in India; therefore, WF coefficients are not sufficiently available to carry out meaningful VW-flows assessment through environmentally extended input-output analysis (Kumar and Jain 2007).

Using WF data, VW-flows embedded in each category of food grains and oilseeds (p) *exported from*[9] each state (s), in a year (t) to other states was estimated through Equation 2.

$$\mathrm{VWX}(\mathrm{s},\mathrm{t}) = \sum_{\mathrm{p}} \mathrm{d}_{\mathrm{p}}^{\mathrm{s}}(s,p,t) * x_p^s(s,p,t)$$

Equation 2

(Chapagain, Hoekstra, and Savenije 2006)

Where, d_p^s is the water intensity or footprint coefficients and x_p^s refers to the quantity of each category of food grains and oilseeds *p* exported. Similarly, VW-flows embedded in each category of food grains and oilseeds *exported to*[10] the state from other states r is estimated using Equation 3.

$$\mathrm{VWM}(\mathrm{s},\mathrm{t}) = \sum_{p} d_p^r(r,p,t) * m_p^r(r,p,t)$$

Equation 3

(Chapagain, Hoekstra, and Savenije 2006)

[9] Exported from: since the analysis is at sub-national scale the notation used is ***exports from*** for ***exports*** (DGCIS)

[10] Exports to: since the analysis is at sub-national scale the notation used is ***exports to*** for ***imports*** (DGCIS)

Where, d_p^r is the water intensity or footprint coefficient in the state *r* of each category of food grains and oilseeds *p* and m_p^r is the quantity of each category of food grains and oilseeds *p* imported from state *r* for the year *t*.

In Equation 2 and Equation 3, each year refers to financial year, i.e., 2003-04 is April 2003-March 2004, because the inter-state movement of agricultural goods data is recorded for financial years and WF data is available as a 9 years average, i.e., 1996-2005.

VW balance of a state is the difference between VW exports and imports, expressed in Equation 4.

VWB(s,t) = VWX(s,t) – VWM(s,t)

Equation 4

(Chapagain, Hoekstra, and Savenije 2006)

National WS ΔS_n (m^3/yr) through inter-state movement of each category of food grains and oilseeds p from an exporting state s_e to an importing state s_i, in Equation 5.

$$\Delta S_n[s_e, s_i, p] = T[s_e, s_i, p] * (VW[s_i, p] - VW[s_e, p])$$

Equation 5

(Chapagain, Hoekstra, and Savenije 2006)

Where T refers to the amount of product which is moved between states. Summing up the national WS of each category of food grains and oilseeds gives total national WS. WS result from differences in water productivities, for instance, if water needed at the site of production (exported from / export) is lower than the site of consumption (exported to/import) (Chapagain and Hoekstra 2004, Wang et al. 2015).This means water is saved in the movement of goods from higher to lower water productivity.

The next section is on the third assessment, i.e., understanding the extent of science-policy interface in the water policies of India to mitigate water scarcity.

3.3. SCIENCE-POLICY INTERFACE

3.3.1. DATA COLLECTION PROCEDURE

Understanding on science-policy interface, particularly in the context of water scarcity was gained through the critical review of national and state water policies, and the outcomes of the first two parts of assessments, i.e., establishing water scarcity situation, and inter-state VW-flows assessment, national and state water policies of India were reviewed. For which, water policy documents were obtained from the repository of Ministry of Water Resources, concerned State Governments' and International Environmental Law Research Centre (IELRC). The State Water Policies (SWPs) which were reviewed along with the three versions of National Water Policy (NWP) (Government of India 1987, 2002a, 2012d) are compiled in Table 3.6.

Table 3.6: State Water Policies

S.No.	Government of States	Year of State Water Policy (SWP)	Source
1	Tamil Nadu	1994	(Government of Tamil Nadu 1994)[11]
2	Uttar Pradesh	1999	(Government of Uttar Pradesh 1999)
3	Goa	2000	(Government of Goa 2000)
4	Karnataka	2002	(Government of Karnataka 2002)
5	Maharashtra	2003	(Government of Maharashtra 2003)
6	Madhya Pradesh	2005	(Government of Madhya Pradesh 2003)
7	Himachal Pradesh	2005	(Government of Himachal Pradesh 2005)
8	Orissa	1994*, 2007	(Government of Orissa 2007)
9	Kerala	2008	(Government of Kerala 2008)
10	Andhra Pradesh	2008	(Government of Andhra Pradesh 2008)
11	Jharkhand	2011	(Government of Jharkhand 2011)
12	Rajasthan	1999*, 2010	(Government of Rajasthan 2010)
13	Chhattisgarh	2001, Draft 2012	(Government of Chhattisgarh 2001, 2012)
***SWP could not be accessed**			

[11] http://www.thehindu.com/news/national/tamil-nadu/water-policy-to-be-revised/article2893747.ece

3.3.2.RESEARCH METHOD

To carry out a critical review of NWPs and SWPs in order to examine the strength of science-policy interface on mitigation of water scarcity, five key indicators were identified. These are water scarcity inducers; water allocation priorities; water use efficiency; water savings; and stakeholder's participation and water literacy. The first four indicators were selected as they are linked with the four approaches to assess water scarcity. For instance, the first indicator, ***water scarcity inducers***, comprises both human and climate-driven water scarcity. Considering climate-driven water scarcity is crucial because climate change is expected to exacerbate water scarcity (Tekken and Kropp 2012). For ensuring water security, there is a need for policy focus on the impact of climate change on water scarcity(Falkenmark et al. 2007).Therefore, this indicator is linked with human water requirements (approach I) and water resources vulnerability (approach II).

The second indicator, ***water allocation priorities***, i.e. among sectors was selected to determine whether environment and ecology figures as a priority. Prioritizing water requirements of environment and ecology in water policies is crucial for strategizing water security and it reflects the existence of science-policy interface(Cook and Bakker 2012). This indicator is linked to approach III on the incorporation of EWR and approach IV on WF and LCIA.

Third and fourth indicators – ***water use efficiency (WUE), and water savings (WS)*** – are associated with water resource vulnerability (approach II), and WF and LCIA (approach IV). This is because technology and infrastructure play a crucial role in enhancing WUE and WS, and is also considered as the criteria for determining water scarcity according to approach II (water resources vulnerability). WUE and WS are linked with approach IV because the approach is a measure of freshwater use. VW-flows assessment would particularly be of interest to policy discourse on WS.

Although the last indicator – ***stakeholder's participation and water literacy*** – does not directly relate to the four approaches to assess water scarcity, the indicator was considered crucial to understanding the extent of the science-policy interface. This is because stakeholders' participation and water literacy are significant in building the strength of the science-policy interface through knowledge transfer, dissemination and research use (Homes and Clark 2008, Wesselink et al. 2013, Ramachandran et al. 2014, Bradshaw and Borchers 2000). Stakeholders' participation is a process through which they influence decision-making and development initiatives. It intends to empower them, enhance efficiency, accountability, sustainability and is a way to build trust among various stakeholders(Dube and Swatuk 2002). Its importance in sustainable development was recognized in UNCED 1992 (Reed 2008). It is desired in decentralized water management, i.e., at the 'lowest appropriate level'(Dube and Swatuk 2002). It is an indicator of *social equity and justice* (Reed 2008). Water literacy refers to developing a balanced perspective on water.It is instrumental in generating awareness, co-creating water management strategies to enhance sustainability both in the present and future(Hawke 2012, Sammel and Mcmartin 2014).

Chapter 4 WATER SCARCITY IN INDIA[12]

This chapter presents the findings of water scarcity situation at the state level in India. It is formulated on the basis of literature review and analysis. The data and research method for the analysis are discussed in the previous chapter's section 3.1. This chapter is organized into two sections. The first section gives a brief overview of the various approaches to assess water scarcity. The second section comprises the water scarcity situation in states of India according to these approaches.

4.1. APPROACHES TO ASSESS WATER SCARCITY

Water scarcity is a multifaceted issue and 'plural normative views' on water scarcity are reflected in the various approaches and indices used to assess it through indices (Mehta 2011, Jaeger et al. 2013). In the following section, the approaches and indices have been used to assess sub-national water scarcity for India are discussed (listed in Figure 3.1).

4.1.1. APPROACH I: HUMAN WATER REQUIREMENTS

The first set of indices considers freshwater scarcity as a relationship between available water resources and the human population and are therefore classified under the approach I, i.e., on ***human water requirements.*** The scale of analysis is usually an administrative unit (Rijsberman 2006, Brown and Matlock 2011). Falkenmark indicator (1989) is the only index, emerging from this approach, through which water scarcity in India has been assessed (Figure 3.1, and Table 3.1).

[12] Sections of this chapter have been published in Water Policy journal in 2016 entitled '*Water Policy at science-policy interface - challenges and opportunities for India*'

Falkenmark Indicator has been used to assess water scarcity at administrative (national) and hydrological (river basins) scale for India (Figure 4.1). At the national scale, three independent estimates of water stress are available. These estimates are from NCIWRD Government of India (1999),Narasimhan (2008),Garg and Hassan (2007) and reflect that India has transitioned from water stress (1000 m^3/ capita/year) to water scarcity (500-1000 m^3/capita/year) and by 2025 will be water-scarce with per capita water availability of the magnitude of 481 to 782 m^3/ capita/year. The water scarcity scenario worsens by 2050 as there is a further depletion in the per capita water availability per year to below 500m^3/capita/year, indicated by the estimates of Narasimhan (2008), and Garg and Hassan (2007).

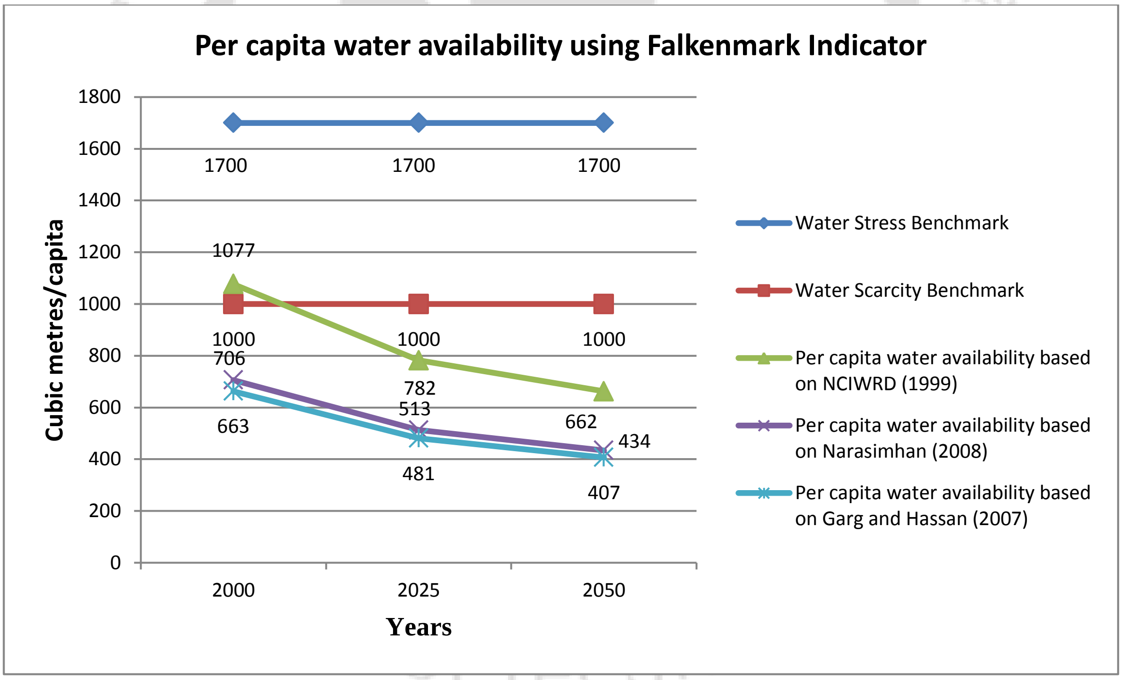
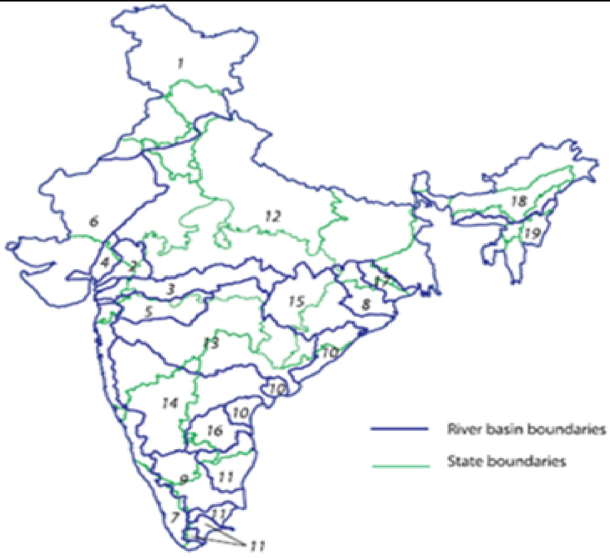


Figure 4.1: Per capita water availability using Falkenmark Indicator

Source: TERI (2008)

The national average of water availability for human use was 1816 m^3/capita/year in 2001 and 1731m^3/capita/year in 2004 and reflected no water stress. However, it has been declining and has become a concern since 2010 with water availability falling below the water stress benchmark of 1700 m^3/capita/year, to 1608 m^3/capita/year. It continues to fall, as evident from the water availability of 1544 m^3/capita/year in 2011 and is projected to be 1140 m^3/capita/year in 2050 by Central Water Commission which is close to the water scarcity benchmark of 1000 m^3/capita/year (Government of India 2013c).All these estimates raise concern over aggravating water scarcity and lack of adequate efforts to mitigate it.

At a higher resolution, i.e., at the river basin scale, significant spatial variations in water scarcity were observed. For instance, average water availability in Ganga-Brahmaputra-Meghna system was 2045 m^3 /capita/year while it was alarmingly low in Sabarmati basin (263 m^3/capita/year) in 2010. Along with Sabarmati the water-scarce basins of India are Krishna, Cauvery, Subernarekha, Pennar, Mahi, Sabarmati, Tapi, East Flowing Rivers and West Flowing Rivers of Kutch and Saurashtra including Luni with water availability of less than 1000m^3/ capita/year (Figure 4.1, and Figure 4.2) Among these Cauvery, Pennar, Sabarmati and East Flowing rivers and West Flowing Rivers of Kutch and Saurashtra including Luni experience acute water scarcity with water availability of approximately 500 m^3/ capita/year or less(Falkenmark, Lundgvist, and Widstrand 1989, Government of India 2013c). The limitation of Falkenmark Indicator is the inability to account the renewable water supply, the annual demand for water in a nation, and inability to capture water stress or scarcity at smaller scales(Rijsberman 2006, Brown and Matlock 2011).These limitations were overcome by the second approach as the focus of water scarcity assessment was on water resources vulnerability.



River basins

1. Indus
2. Mahi
3. Narmada
4. Sabarmati
5. Tapi
6. Westerly flowing rivers- Group1
7. Westerly flowing rivers-Group 2
8. Brahmani and Baitrani
9. Cauvery
10. Easterly flowing river-Group 1
11. Easterly flowing river- Group 2
12. Ganga
13. Godavari
14. Krishna
15. Mahanadi
16. Penner
17. Subarnarekha
18. Brahmaputra
19. Meghna

Figure 4.2: River and state boundaries of India
Source:de Fraiture et al. (2004)

4.1.2. Approach II: Water Resources Vulnerability

The second approach to assess water scarcity is based on ***water resources vulnerability*** and accounts water requirements of economic sectors in addition to that of the human population. Therefore, it estimates the water use for domestic, agricultural and industrial purposes. The approach considers the water losses from a reservoir in the form of evaporation also. Technology and infrastructure are the key aspects of determining water scarcity according to this approach. Water scarcity is measured on the basis of the ratio of total annual withdrawals to available water resources (WTA ratio) (Brown and Matlock 2011, Raskin et al. 1997, Jaeger et al. 2013).

The indices belonging to this approach, and have been used to assess water scarcity of India are Index of Local Relative Water Use and Reuse (Vorosmarty et al. 2005), Physical and

Economic Water Scarcity (IWMI 2008a), Potential Storage Index (Columbia Water Centre 2011) and Drought Index(Government of India 2014c) (Figure 3.1, and Table 3.1).

The Index of Local Relative Water Use and Reuse has two components, i.e., local relative water use and water reuse. The ***index of local relative water use*** is a ratio of the water withdrawals for domestic, industrial and agricultural purposes in the cells of 8 km each and the river corridor discharges[13]. The ***water reuse index*** is a ratio of total water use from all cells and the river corridor discharge. The index score of greater than 0.4 indicates a high level of stress. Most of the zones in India except a part of North and the North-East lie in the zone of 0.8 to 1.0 depicting a very high level of water stress and the threat to human water security. A part of north and northeast India has a score of approximately 0.4, depicts moderate human water security threat.

The second index, ***Physical and Economic Water Scarcity***, was developed by IWMI (2008a) to determine the fraction of renewable freshwater resources which are available for meeting the human requirements. The index integrates existing water infrastructural facilities for main water supply. The physical and economic water scarcity is usually measured at river basin scale and then aggregated to the national level to make an international comparison. 'Physical water scarcity' is indicated by the withdrawal of more than 75% of river flows for domestic, agriculture, and industrial use. Occurrence of physical water scarcity entails acute environmental degradation, groundwater exploitation, and inefficient and inequitable water allocation(Molden 2007). Physical water scarcity does not necessarily occur in the dry region because it is indicated by water use in relation to water available. 'Economic water scarcity', in contrast, refers to the situation with adequate renewable water resources, but the withdrawal of less than 25% of river waters for use; scarcity is primarily reflected through

[13] River corridor discharges is a sum of the local discharges which are estimated by taking the product of runoff and the area of the cell of 8 km each (Vorosmarty et al. 2005)

very limited water infrastructural facilities to access water resources(Seckler, Molden, and Barker 1998). According to the index, there is a spread of the physical as well as economic water scarcity (Figure 4.3). While Southern, Western and Northern zones face physical water scarcity; Eastern and Northeastern face economic water scarcity. A part of Central India is approaching physical water scarcity. There is hardly any basin with *little or no water scarcity*, except a portion of Indus basin in North India.

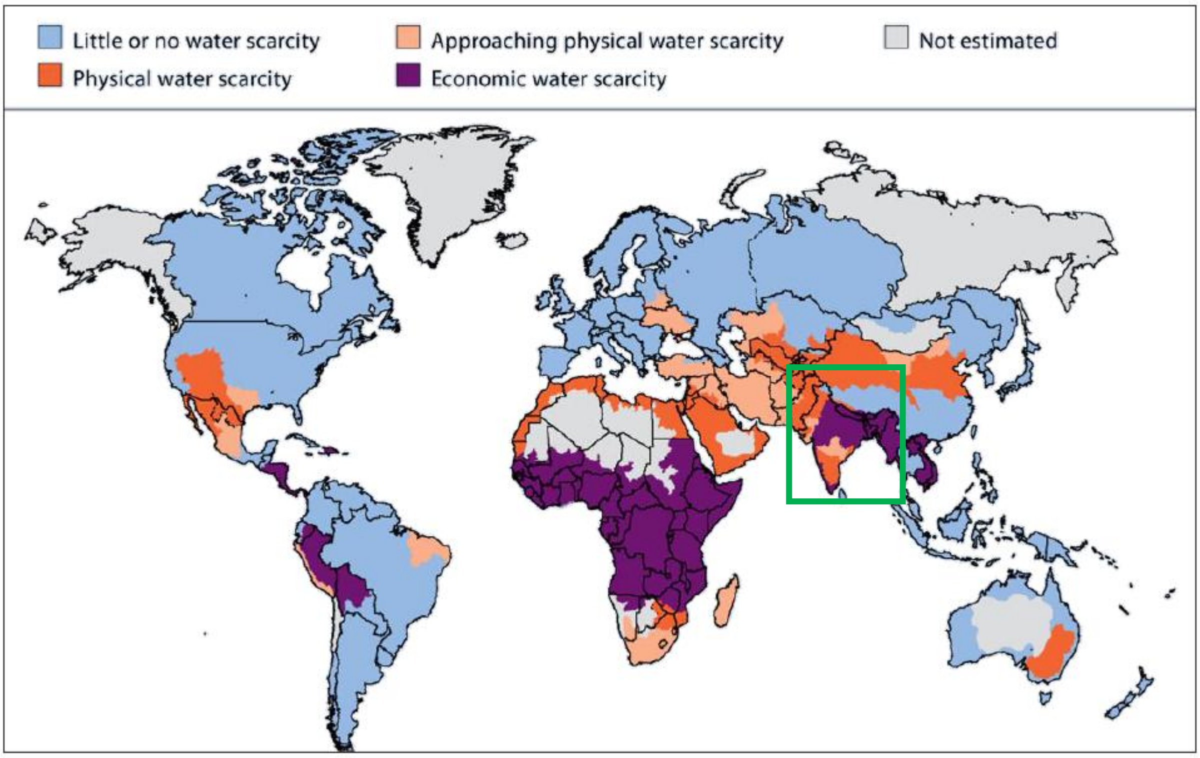


Figure 4.3: Physical and economic water scarcity in the river basins of the world in 2007
Source:IWMI (2008a)

The India Water Stress Index, also known as the Potential Storage Index (PSI), was developed by Columbia Water Centre with the rationale that there are periodic shocks due to water stress in both short-term as dry spells within a year (described as normalized deficit index for a median year in Figure 4.4); and in long-term as droughts from year to year (normalized deficit index multiyear maximum in Figure 4.4). The index determines the magnitude of water storage capacity as well as its potential at the district level in India (Columbia Water Centre 2011). It emphasizes on the role of infrastructure, specifically, water storage capacity, to build coping capacity to droughts and to mitigate other climate change risks to water resources. The index is based on 100 years data on precipitation and temperature. The findings of the index suggest that India has insufficient water storage capacity at present and there are regional variations in vulnerability to both short and long-term water shortages. The regions in India with short-term water shortages receive enough rainfall to meet the water needs; the storage structures suggested to cope with water stress are reservoirs, ponds, and tanks. On the other hand, the long-term water shortages are faced by the regions which are critically water-stressed; the storage structures suggested are large-scale infrastructures, like dams and water transfer infrastructure. Punjab in Northwestern zone of India has a score of more than 100 on normalized deficit index of multiyear maximum reflect highest water stress in the long term. Haryana, Rajasthan and some districts of Gujarat indicate moderate to high water stress with a score of 11-100.Water stress is also reflected in districts of Uttar Pradesh, Bihar, West Bengal, and Andhra Pradesh (with an index score of 1.1-2.0).

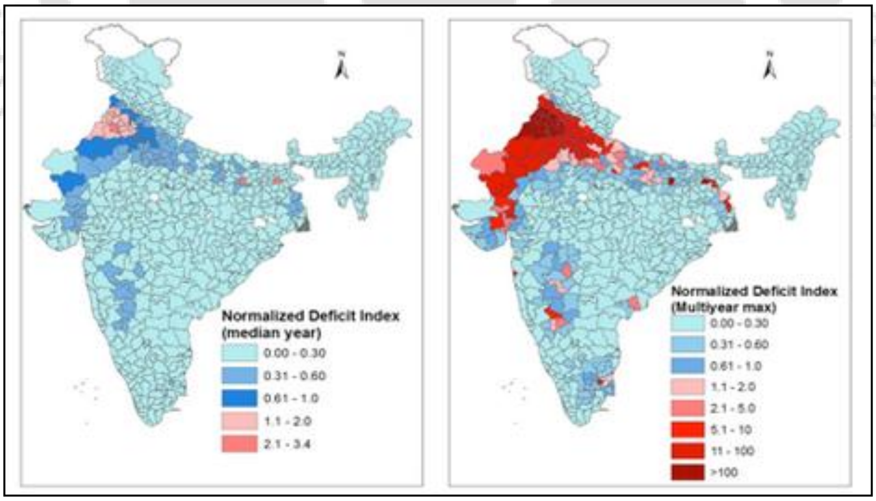


Figure 4.4: India Water Stress Index
Source: Columbia Water Centre (2011)

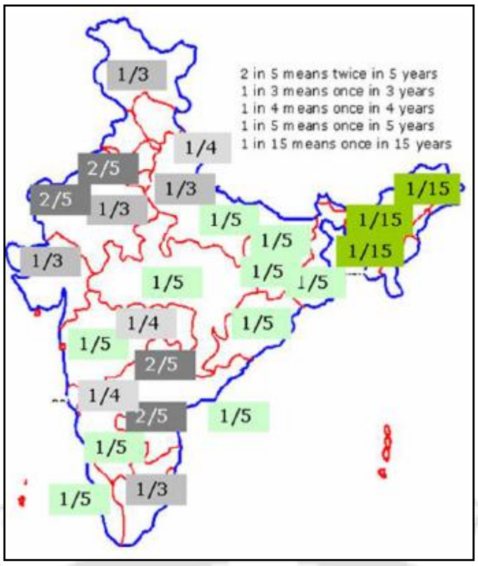


Figure 4.5: Drought Map of India
Source: Government of India (2014c)

The findings of India Water Stress Index are in agreement with that of Ministry of Agriculture on droughts. To illustrate Punjab, Rajasthan, Haryana and Andhra Pradesh are also the most drought-prone states with a frequency of drought twice every five years (Figure 4.5). Gujarat and Uttar Pradesh states are among second highest vulnerable to drought as they experience droughts once every three years. The contrast in the findings of the two indices is for Jammu and Kashmir, Himachal Pradesh and Tamil Nadu. These states lie in the second highest category of vulnerability to droughts but have low vulnerability according to India Water Stress Index. This is primarily because of relatively better storage infrastructural facilities to cope with water stress (Government of India 2014c, Columbia Water Centre 2011).

This approach does not integrate the environmental water needs, which was overcome by the third approach, discussed in the subsequent sub-section.

4.1.3. APPROACH III: INCORPORATION OF ENVIRONMENTAL WATER REQUIREMENTS (EWR)

The significance of meeting water requirements of the environment and natural ecosystems was emphasized upon in the Dublin Conference in 1991 (ICWE 1992). The consequences of not meeting the environmental flows (e-flows) adequately are high costs for medium to long-term in dealing with public health risks, loss of food security, damage to livelihoods, loss of biodiversity and increased water-related conflicts. The EWR based water scarcity analysis is usually carried out at basin level(Smakhtin, Revanga, and Doll 2005).

EWRs[14] were integrated into the assessment of water scarcity by Smakhtin, Revanga, and Doll (2005) through the development of the Water Stress Indicator (WSI) at river basin scale (Figure 4.6). Smakhtin, Revanga, and Doll (2005) considered EWR as a crucial component of water use. In the assessment, total water availability is expressed by a proxy of Mean Annual Runoff (MAR) of rivers and EWR is represented as a percentage of it. Interestingly, when water scarcity is analyzed using the EWR approach in comparison to not considering EWR, it reflects a higher magnitude of water stress as it considers water needs of people, economy, and the environment.

India is a special case of large regional variation in water stress and scarcity according to the findings of the WSI. It ranges from -

- Low water stress in the Brahmaputra, Barak, Mahanadi, West flowing rivers from Tapi to Tadri, and Tadri to Kanyakumari with an index score of WSI<0.3;.
- Moderate water stress in Ganga, Indus, Godavari, East flowing rivers and between Pennar and Kanyakumari with an index score of 0.6< WSI < 0.7; to

[14] Environmental flows are also known as 'minimum flows', 'environmental demand' and 'in-stream flow requirements' (Smakhtin, Revanga, and Doll 2005)

- High water stress in the Narmada, Cauvery, Tapi, Krishna, Pennar, Brahmani and Baitrani, Subernarekha, and Westerly flowing rivers of Kutch and Saurashtra including Luni with the index score of WSI ≥ 1(Figure 4.2, and Figure 4.6).

In addition, EWRs are not uniform for all the rivers; they vary with the flow of the rivers. The interpretation of the relationship in the variability[15] of river flow and the EWR is such, that least variability in the river flows[16] reflects highest EWR, e.g. Brahmaputra and Ganga, highest variability reflects least EWR, e.g. Mahi and Sabarmati in all the environment management classes[17](Smakhtin and Anputhas 2006).

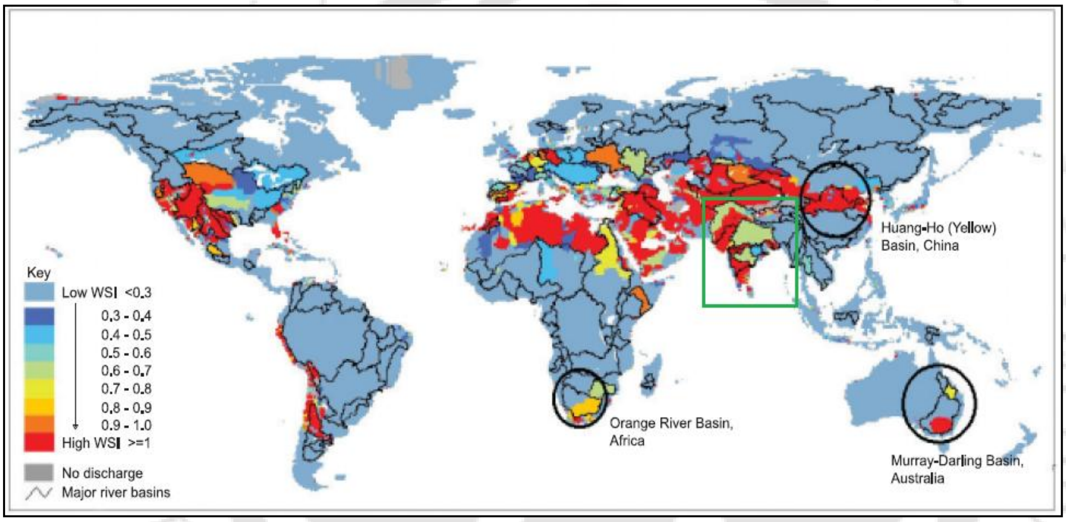


Figure 4.6: Water Stress Index using EWR
Source: Smakhtin, Revanga, and Doll (2005)

Although approach III captures a crucial dimension of water scarcity, i.e., EWR, it does not consider the water use in the entire life cycle of a product, i.e., from cradle to grave. This is gauged through approach IV.

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[15] The variability of the environmental flow (e-flow) is reflected from the analysis of the simulated river flow records and corresponding standardized flow duration curves (FDC). The steepness of the FDC indicates the extent of variability

[16] River flows measured by the proxy of mean annual runoff

[17] Environment Management Classes: A: Natural; B: Slightly modified; C: Moderately modified; D: Largely modified; E: Seriously modified; F: Critically modified. EWR is about 60-70% of natural MAR to maintain a river in the natural (A) or slightly modified (B) class; 25-33.3% of natural MAR is needed to maintain the ecological health in unmodified state (C) and 10% of natural MAR is essential to maintain the least ecological functions of the extremely modified (E and F) rivers (Smakhtin and Anputhas 2006)

4.1.4. Approach IV: Life Cycle Assessment (LCA) and Water Footprint (WF)

Approach IV integrates the water consumption in the entire life cycle of a product and also quantifies the potential environmental damages of water use on human health, ecosystem quality, and resources(Pfister, Koehler, and Hellweg 2009). There are two measures, Life Cycle Impact Assessment (LCIA) and Water Footprint (WF) The LCIA score of 0.01 reflects minimum water stress and a score greater than 0.5 as severe stresses. India, to a large extent, is extremely water stress with a score of greater than 0.9, except Indus in the North (index score of 0.3) and Brahmaputra and Barak in Northeast (index score <0.1).

As discussed in section 2.1, the concept of WF[18] has evolved since its conception in 2003. WF captures the variation in water scarcity within a year and from year to year. The water scarcity is estimated at various governance scales. In India there is a variation in water scarcity within a year, it is measured as the number of months in which river basin face greater than 100% water scarcity. For instance, Brahmaputra and Barak basin are not water-scarce (0 months). Mahanadi has low water scarcity (4-5 months). Ganga, Krishna, Narmada, and Godavari face moderate water scarcity (5-6 months) and Indus, Cauvery and westerly flowing rivers face very high water scarcity all around the year (Figure 4.2).The water scarcity level of states of India was determined based on the findings of indices of these four approaches using the research method discussed in section 3.1.2.The water scarcity situation at state level is discussed in the subsequent section.

4.2. Water Scarcity Situation at State Level

The methodological steps followed to determine the water scarcity level of a state is depicted in Figure 4.7 with an example of Himachal Pradesh state. For instance, the state is moderate

[18] WF is defined as the volume of freshwater used to produce the product, measured over the full supply chain. (Hoekstra and Chapagain 2007)

to highly water-scarce based on aggregation of all the four approaches. While the indices of the first two approaches indicate it to be moderately water-scarce, approach III, which incorporates EWR, indicate it to be moderate to highly water-scarce. The findings of approach IV reflect that the state is facing high water scarcity.

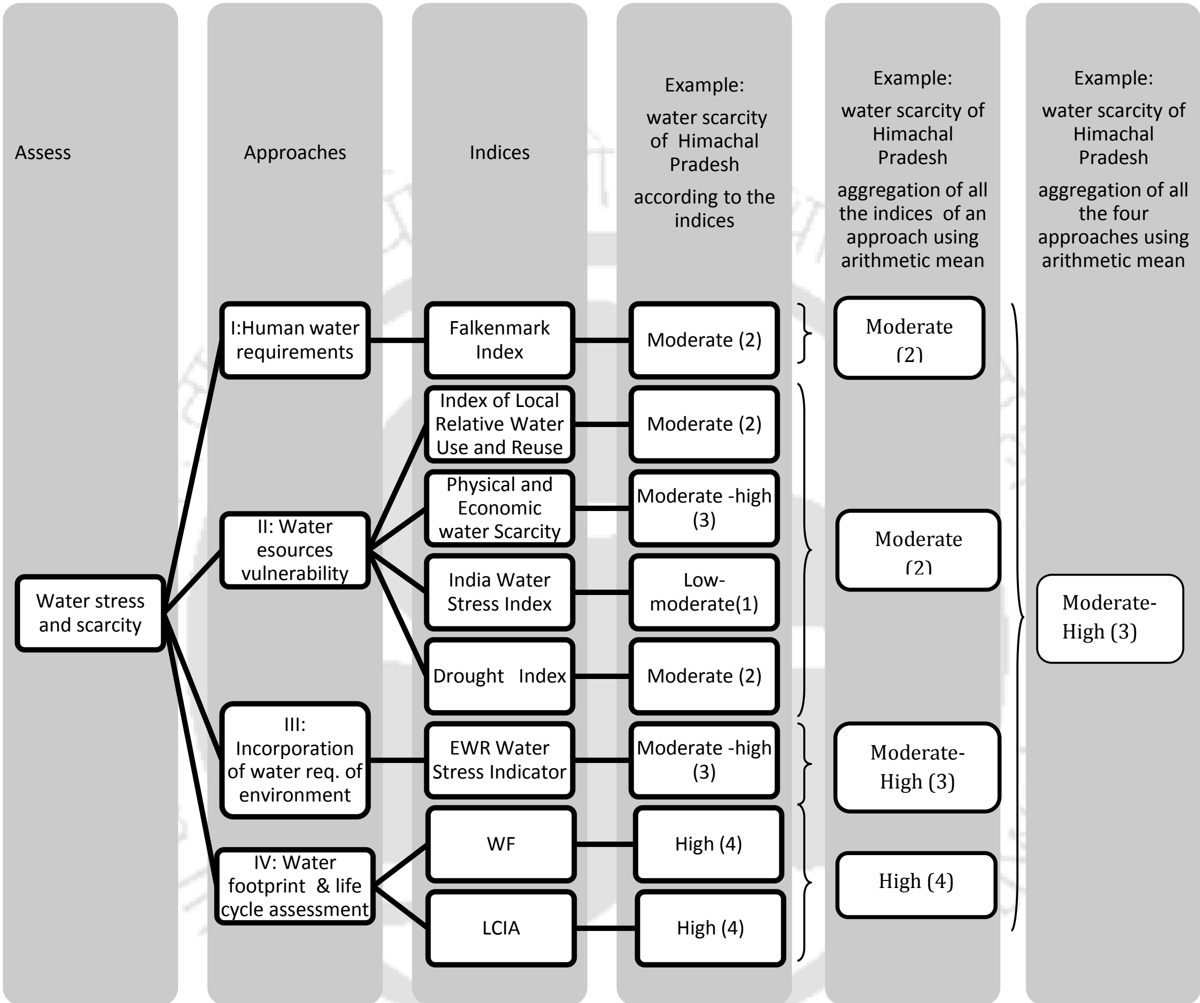

Figure 4.7: Methodological steps through an example of water scarcity level of Himachal Pradesh
Source: Author's own

A variation can be seen in the water scarcity of states in India (Figure 4.8). It ranges from low to moderate water scarcity in states of North-East zone; moderate in states of Central and East; moderate to high in states of North, South, and West; to high water scarcity in states of South, North, and West zones (Appendix 1: Classification of States into Zones).

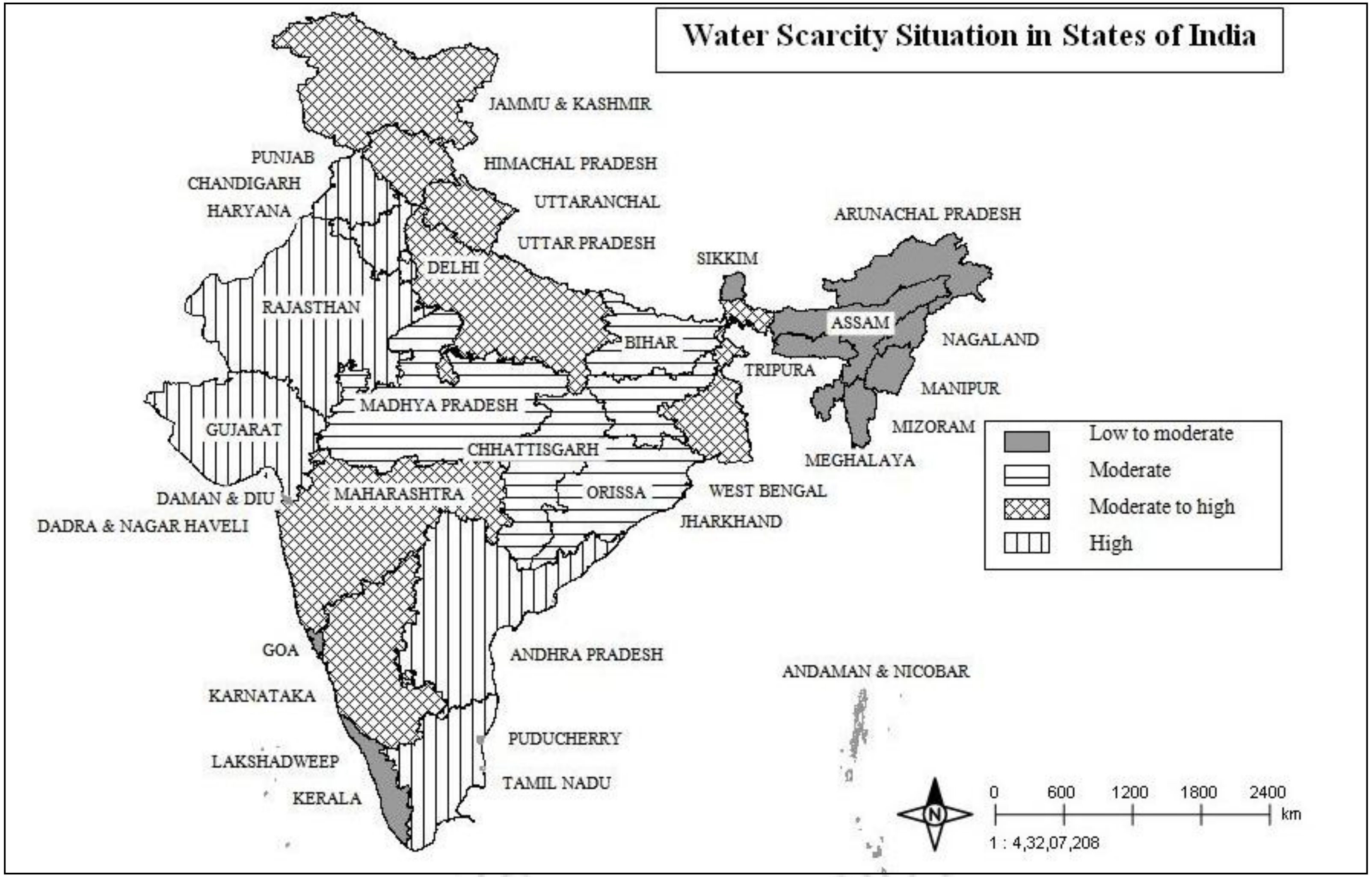

Figure 4.8: Water Scarcity Situation in States of India
Source: Author's own

States of North-East zone are the most water abundant in India and are least prone to droughts with the frequency of occurrence of drought as once in every fifteen years[19] (Government of India 2014c, 2009a). Despite being water abundant, they are considered to be low to moderately water-scarce, primarily because they face economic water scarcity[20], and their water resources experience low water stress according to approach III and IV(IWMI 2008a, Smakhtin, Revanga, and Doll 2005). In addition to the states of North-East zone, Kerala from the South and Goa from the West experience low to moderate water scarcity (Table 3.1, and Figure 4.8).

Bihar and Orissa from Eastern, and Chhattisgarh, and Madhya Pradesh from Central zones of India face moderate water scarcity. This is because states of Central zone are approaching physical water scarcity, while states of Eastern zone face economic water scarcity (IWMI 2008a). Further, the frequency of droughts in these states is once in five years(Government of India 2014c). The river basins of these states, such as East flowing rivers experience moderate water stress, while Brahmani, Baitrani, and Subernarekha experience high water stress according to approach III. Approach IV indicates that Mahanadi and Ganga basins in Eastern zone experiences 4-5 months, and 6-7 months of water scarcity in a year, respectively (Table 3.1, and Figure 4.8).

States of North, South, and West zones experience moderate to high water scarcity. This is reflected through Falkenmark Indicator (approach I) that water availability has declined below the water scarcity benchmark in river basins of the states. In addition, indices of approach II reflect that these zones face physical water scarcity. The states are prone to droughts once in every three to four years. Further, Indus basin in North, and Krishna in the Southwest experience moderate and high water stress considering their EWRs. According to

[19] Drought Index: from Approach II
[20] Economic water scarcity: Physical and Economic Water Scarcity from Approach II

approach IV, Indus and westerly flowing rivers experience high water scarcity throughout the year. Therefore, Himachal Pradesh, Uttaranchal, Uttar Pradesh in the North and Maharashtra in the West and Karnataka in South are among the moderate to highly water-scarce states (Figure 4.8).

High water scarcity is being experienced by Punjab, Haryana in North; Rajasthan and Gujarat in West; and Andhra Pradesh and Tamil Nadu in South. This is because river basins of the state are facing absolute water scarcity with the water availability of less than $500m^3$/capita/year (Table 3.1, and Figure 4.8). Indices of approach II reflect a very high level of water stress and a threat to human water security in these states. For instance, India Water Stress Index reflects that Punjab, Haryana, Rajasthan, and Gujarat, in particular, experience high water stress due to low potential of water storage (Figure 4.4). They are highly prone to droughts with the frequency of droughts as high as twice in every five years, and once in every three years (Figure 4.5). Further, according to approach III and IV, high water stress is being experienced by Narmada, Cauvery, Tapi, Krishna, Pennar, Westerly flowing rivers of Kutch and Saurashtra (including Luni) river basins of states in the North, West, and South India (Figure 4.8).

It is crucial to emphasize here that moderately to highly, and highly water-scarce states like Punjab, Haryana, Uttar Pradesh, Uttaranchal, Jammu & Kashmir, Himachal Pradesh states of North, Gujarat, Maharashtra, Rajasthan states of West and Andhra Pradesh, Karnataka, Tamil Nadu states of South are also major producers of food grains (Figure 4.8, and Table 3.2). Among them, the states located in West and South zones are also the major producers of oilseeds (Figure 4.8, and Table 3.3). Therefore, assessment of inter-state VW-flows embedded in food grains and oilseeds would be significant to understand the sustainability of VW-flows in terms of water scarcity. That is, whether the inter-state VW-flows lead to the distribution of water scarcity or concentration of water scarcity in already highly water-scarce states. The next chapter dwells upon the results of VW-flows assessments at national, zonal and state level.

Chapter 5 VIRTUAL WATER FLOWS: NATIONAL AND SUB-NATIONAL SCALE[21]

This chapter presents the results of the second assessment, i.e., VW-flows assessment. It is organized into two sections. The first section deals with WF coefficients and the second section is on VW-flows. The discussion in both the sections begins with food grains and oilseeds in 1996-2005 followed by that of 2005-2014 at national and sub-national, i.e., zonal and state, levels.

5.1. WATER FOOTPRINT

It was considered important to discuss the spatial and temporal variations in WF because it is a crucial component of the VW-flows conceptual framework (as discussed in section 2.1) and emerges from the latest approach of assessing water scarcity and reflects the water intensity of production (discussed in section 4.1.4). The discussion in this section is organized in four parts- (1) national averages of WF coefficients of food grains and oilseeds for the post-reforms period (1996-2005); (2) national averages of WF coefficients of food grains and oilseeds for the period of recovery (2005-2011) up to 2014; (3) zone and state level WF coefficients of food grains and oilseeds for the post-reforms period (1996-2005); and (4) zone and state level WF coefficients of food grains and oilseeds for the period of recovery (2005-2011) up to 2014.

[21] Sections of this chapter have been submitted to Water Resources Research journal in 2016, entitled '*Assessment of Regional Virtual Water Flows in India (1996-2014)*' (To be revised and resubmitted).

5.1.1. NATIONAL LEVEL (1996-2005)

5.1.1.1. FOOD GRAINS

Among the food grains categories considered, sorghum and millets has the highest WF (5028 m^3/ton) in the period of 1996-2005 (Table 5.1). Approximately 94% of its WF content was green WF[22], contributed through rainfed agriculture. The least WF is of rice in the husk (2070 m^3/ton) and wheat (2100 m^3/ton). These are irrigation-intensive crops, and that is why Wheat has the highest blue WF (56%). Production of pulses other than gram is associated with the highest wastewater generated, i.e., grey WF (31%).

Table 5.1: National Average Water Footprint of Food Grains in 1996-2005

Food grains	National average WF in 1996-2005 (m^3/ton)	Proportion of different types of WF (%)		
		Green	Blue	Grey
Rice in the husk	2070	67	22	11
Rice not in the husk	2688	67	22	11
Wheat	2100	30	56	14
Wheat flour	2125	30	56	14
Gram and gram products	4026	79	2	19
Pulses other than gram	3550	59	10	31
Sorghum and millet	5028	94	2	4
Maize and millets	3283	91	3	7
Other sorts of grains	3076	81	14	5

Source: Compiled from Mekonnen and Hoekstra (2010) and Mekonnen and Hoekstra (2011)

5.1.1.2. OILSEEDS

Among oilseeds, castor oil has the highest WF (23122 m^3/ton) in the period of 1996-2005 (Table 5.2). Approximately 82% of its WF content is green WF, and 15% is blue WF. The highest proportion of green WF is of other vegetable oil (93%), blue WF is of mustard oil (44%), and grey WF is of oilseeds of cotton (10%). The least WF is of oil cakes (3344 m^3/ton). Except mustard oil, oilseeds are predominantly produced through rainfed agriculture.

[22] Green WF: discussed in section 2.1

Table 5.2 : National Average Water Footprint of Oilseeds in 1996-2005

Oilseeds	National average WF in 1996-2005 (m^3/ton)	Proportion of different types of WF (%)		
		Green	Blue	Grey
Oilseeds cotton	9321	70	20	10
Oilseeds other than cotton	15233	92	3	5
Ground nut oil	9258	84	10	6
Mustard oil	6437	49	44	7
Castor oil	23122	82	15	2
Other vegetable oil	20775	93	3	4
Oil cakes	3344	89	8	3

Source: Compiled from Mekonnen and Hoekstra (2010)and Mekonnen and Hoekstra (2011)

5.1.2.National Level (2005-2014)

5.1.2.1. Food Grains

The proportions of green, blue, and grey WF in the two periods are same as the type of agriculture, i.e., irrigated and rainfed agriculture has not changed significantly. However, production has intensified to enhance the yield. Therefore, sorghum and millets, wheat and pulses other than gram continue to have the highest proportions of green, blue, and grey WF respectively. The WF have reduced due to improved yields, for instance, WF of sorghum and millet has reduced from 5028 m^3/ton in 1996-2005 to 3669 m^3/ton in 2005-2014 (Table 5.1, and Table 5.3). Wheat (1920 m^3/ton) and rice in the husk (1925 m^3/ton) continue to have the least WF. Their WF has also decreased from 1996-2005 to 2005-2014 (Table 5.1, and Table 5.3).

Table 5.3: National Average Water Footprint of Food Grains in 2005-2014

Food grains	National average WF in 2005-2014 (m^3/ton)	Proportion of different types of WF (%)		
		Green	Blue	Grey
Rice in the husk	1925	67	22	11
Rice not in the husk	2183	67	22	11
Wheat	1920	30	56	14
Wheat flour	1943	30	56	14
Gram and gram products	3599	79	2	19
Pulses other than gram	3099	59	10	31
Sorghum and millet	3669	94	2	4
Maize and millet	2742	91	3	7
Other sorts of grains	2713	81	14	5

Source: Author's own, estimates are based on Equation 1

5.1.2.2. OILSEEDS

There has been also been a decrease in the WFs of oilseeds from 1996-2005 to 2005-2014 due to improvement in yield (Table 5.2 and Table 5.4). Among the oilseeds, other vegetable oils have the highest WF, i.e., 17528 m^3/ton during 2005-2014. Castor oil which had highest WF in 1996-2005, has second highest WF in 2005-2014 (16999 m^3/ton) .Oil cakes continue to have the lowest WF (2825 m^3/ton).

Table 5.4: National Average Water Footprint of Oilseeds in 2005-2014

Oilseeds	National average WF in 2005-2014 (m^3/ton)	Proportion of different types of WF (%)		
		Green	Blue	Grey
Oilseeds cotton	7026	70	20	10
Oilseeds other than cotton	12869	92	3	5
Ground nut oil	7775	84	10	6
Mustard oil	5318	49	44	7
Castor oil	16999	82	15	2
Other vegetable oil	17528	93	3	4
Oil cakes	2825	89	8	3

Source: Author's own, estimates are based on Equation 1

After getting an insight of the national averages of WF, it is crucial to look at the sub-national variations, i.e. at the zonal and state level. The next sub-section dwells upon the zonal and state level WF of food grains and oilseeds during 1996-2005 followed by 2005-2014.

5.1.3. ZONE/STATE LEVEL (1996-2005)

5.1.3.1. FOOD GRAINS

West zone has highest and North has second highest WF of producing most of the food grains (Table 5.5). States of these zones are also major producers of food grains despite being highly water-scarce (Table 3.2, and Figure 4.8). For instance, Haryana, Punjab, and Uttar Pradesh states of North are among the major producers of rice (Table 3.2, Table 5.5, Appendix 2, and Appendix 3). Gujarat, Maharashtra, and Rajasthan of West zone are major producers of gram and gram products, pulses other than gram, sorghum and millet, maize and millet (Table 3.2, Table 5.5, and Appendix 6 to Appendix 9). Rajasthan is also a major producer of other sorts of grains. Haryana and Uttar Pradesh from North zone are among major producers of gram and gram products. Along with these two states, Himachal Pradesh, Jammu and Kashmir, Punjab, and Uttaranchal states are major producers of other sorts of grains. In addition to West and North zone, South zone has a high WF of producing food grains and still is a major producer of food grains (Table 3.2, and Table 5.5). For example, Andhra Pradesh, Karnataka, and Tamil Nadu states of South zone are major producers of pulses other than gram, sorghum and millet, and maize and millet. Lastly, Central zone has the highest WF of wheat, Madhya Pradesh state of the zone is a major producer of wheat (Table 5.5, Table 3.2, Appendix 4 and Appendix 5). Production of food grains in highly water-scarce zone where the production is highly water-intensive (high WF, primarily blue and grey WF) is a concern.

Table 5.5: Zonal Average Water Footprint of Food Grains in 1996-2005

Food grains	**WF in Zones in 1996-2005**					
	North-East	**East**	**Central**	**South**	**North**	**West**
Rice in the husk	1844	1865	1947	2295	2354	2669
Rice not in the husk	2395	2421	2529	2981	3057	3467
Wheat	1805	1948	4142	3800	1427	3738
Wheat flour	1827	1971	4191	3681	1444	3782
Gram and gram products	2632	3300	3561	4043	4304	4698
Pulses other than gram	2285	3468	3855	4511	1989	4384
Sorghum and millet	2763	4323	4283	5193	4796	5773
Maize and millets	2318	2595	2698	3280	3226	3910
Other sorts of grains	2180	2602	2581	2120	2659	2874
Highest WF is highlighted in orange, and second highest WF is highlighted in grey.						

5.1.3.2. OILSEEDS

In 1996-2005, West, South and Central zones have the highest and second highest WF of oilseeds (Table 5.6). States located in these zones are among major producers of oilseeds despite high water scarcity (Table 3.3, and Figure 4.8). To illustrate, Gujarat, Rajasthan, Maharashtra from West zone are major producers of oilseeds of cotton, oilseeds other than cotton, other vegetable oils, and oil cakes (Table 3.3, Appendix 11, Appendix 12, Appendix 16, and Appendix 17). Gujarat and Rajasthan of West zone are also major producers of castor oil (Appendix 15). Andhra Pradesh, Karnataka, and Tamil Nadu states of South zone are among major producers of oilseeds other than cotton, groundnut oil, and other vegetable oil (Appendix 12, Appendix 13, and Appendix 16). Madhya Pradesh from Central zone is a major producer of oilseeds of cotton, and mustard oil (Appendix 11 and Appendix 14). West Bengal of East zone is a major producer of mustard oil despite being the zone with second highest WF (Appendix 14).

Table 5.6: Zonal Average Water Footprint of Oilseeds in 1996-2005

Oilseeds	**WF in Zones in 1996-2005**					
	North-East	**East**	**Central**	**South**	**North**	**West**
Oilseeds cotton	6135	7302	8151	6871	7714	7804
Oilseeds other than cotton	10746	13360	14359	17863	2952	19183
Ground nut oil	8290	9600	6409	11260	8108	6604
Mustard oil	5502	6546	7214	6018	5152	3662
Castor oil	17859	22034	24116	23696	16844	25803
Other vegetable oil	13564	17724	18411	25340	24165	25153
Oil cakes	2316	2768	3126	3638	3457	3838
Highest WF is highlighted in orange, and second highest WF is highlighted in grey.						

5.1.4. ZONE/STATE LEVEL (2005-2014)

5.1.4.1. FOOD GRAINS

West zone continues to have highest WF for some food grains in 2005-2014. South zone has emerged as the zone with the second highest WF of most of the food grains in 2005-2014, while it was North zone in 1996-2005 (Table 5.5, and Table 5.7). Highly water-scarce states of these zones continue to be major producers of food grains (Table 3.2, and Figure 4.8). For instance, Gujarat, Maharashtra, and Rajasthan states of West zone are among major producers of pulses other than gram, and Rajasthan is also the major producer of other sorts of grains (Table 3.2, Figure 4.8, Table 5.7, Appendix 23 and Appendix 26). Andhra Pradesh, Karnataka, Tamil Nadu states of South are among major producers of rice, pulses other than gram, sorghum and millet, maize and millet (Table 3.2, Appendix 18, Appendix 19, Appendix23, Appendix 24, and Appendix 25). Andhra Pradesh and Karnataka are also major producers of gram and gram products (Appendix 22). Haryana and Uttar Pradesh of North zone continue to be a major producer of gram, and gram products despite having a high WF (Appendix 22). Along with Uttar Pradesh, Himachal Pradesh and Uttaranchal states from North zone are major producers of maize and millet (Appendix 25). Madhya Pradesh of Central zone continues to be a major producer of wheat despite having a high WF (Appendix 20, and Appendix 21). Lastly, Bihar, Jharkhand, and West Bengal states of East zone are major producers of other sorts of grains even though the zone has second highest WF (Appendix 26).

Table 5.7: Zonal Average Water Footprint of Food Grains in 2005-2014

Food grains	WF in Zones in 2005-2014					
	North-East	East	Central	South	North	West
Rice in the husk	1672	1501	1499	2081	1931	2548
Rice not in the husk	2171	1949	1947	2702	2507	3309
Wheat	1513	1851	3614	3248	1256	2141
Wheat flour	1531	1873	3657	3287	1271	2842
Gram and gram products	2445	2833	2999	3680	4303	3067
Pulses other than gram	1941	2995	3260	3943	1787	3932
Sorghum and millet	1773	5875	3512	4517	4365	3147
Maize and millets	2301	2288	2464	2950	2644	2197
Other sorts of grains	1937	2513	2414	2114	2495	3010
Highest WF is highlighted in orange, and second highest WF is highlighted in grey.						

5.1.4.2. OILSEEDS

West and South zones continue to have the highest and second highest WF of most of the oilseeds (Table 5.6, and Table 5.8). States located in these zones are among major producers of oilseeds despite high water scarcity (Table 3.3, and Figure 4.8). For instance, Gujarat, Rajasthan, Maharashtra states of West zone are major producers of oilseeds of cotton, oilseeds other than cotton, and oil cakes (Table 3.3, Appendix 27,Appendix 28, and Appendix

33). Andhra Pradesh, Karnataka, and Tamil Nadu states of South zone are among major producers of oilseeds other than cotton, groundnut oil, castor oil, other vegetable oil, and oil cakes (Appendix 28, Appendix 29, Appendix 31, Appendix 32, and Appendix 33). Madhya Pradesh from Central zone continues to be major producers of oilseeds of cotton, and mustard oil (Appendix 27, and Appendix 30). West Bengal and Orissa states of East zone are among major producers of mustard oil, and castor oil, respectively despite being the zone with second highest WF (Appendix 30 and Appendix 31). Lastly, Haryana, Punjab, and Uttar Pradesh states of North zone are among major producers of other vegetable oil even though the zone has the highest WF of producing it (Table 3.3, Table 5.8, and Appendix 22).

Table 5.8: Zonal Average Water Footprint of Oilseeds in 2005-2014

Oilseeds	**WF in Zones in 2005-2014**					
	North-East	**East**	**Central**	**South**	**North**	**West**
Oilseeds cotton	2384	3831	6182	4319	3867	4562
Oilseeds other than cotton	9926	12515	11549	15165	2331	15868
Ground nut oil	7385	11017	5007	10395	6837	5202
Mustard oil	5051	5267	5984	3081	4487	2899
Castor oil	13559	20880	18886	22138	12383	19579
Other vegetable oil	12473	16810	12575	22418	28573	20935
Oil cakes	2112	2595	2516	3030	2968	3464
Highest WF is highlighted in orange, and second highest WF is highlighted in grey.						

5.1.5. SUMMING UP

It is crucial to emphasize here that the states of zones with the highest and the second highest WF of producing food grains and oilseeds are among major producers of these food grain and oilseeds. Most of these states are facing high water scarcity (assessed in section 4.2), and there is a concern of aggravation of water scarcity with continued production of food grains and oilseeds in these highly water-scarce states. This concern can be adequately addressed through considering VW-flows assessment in economic planning and formulation of water savings strategies. The findings of VW-flows assessment are discussed in the subsequent section.

5.2. VIRTUAL WATER FLOWS

This section consists of the results of VW-flows assessment. The discussion is organized in four sub-sections - (1) VW-flows embedded in food grains and oilseeds at the national level for the post-reforms period (1996-2005); (2) VW-flows embedded in food grains and oilseeds at the national level for the period of recovery (2005-2011) up to 2014; (3) VW-flows embedded in food grains and oilseeds at zone and state level for the post-reforms period (1996-2005); and (4) VW-flows embedded in food grains and oilseeds at zone and state level for the period of recovery (2005-2011) up to 2014.

5.2.1.NATIONAL LEVEL (1996-2005)

At the national level, VW-flows embedded in the inter-state movement of food grains and oilseeds resulted in WS in some years and water losses in other during 1996-2005. These water saving and losses are discussed in this segment.

5.2.1.1. FOOD GRAINS

There were 89235 GL of net WS during 1996-2005 due to the inter-state movement of food grains (Table 5.9). The highest net WS were of 24922 GL in the year 2001-2002, followed by 22330 GL in the year 2004-2005. In both the years WS resulted due to the inter-state VW-flows embedded in wheat, i.e. 14610 GL in 2001-2002 and 24734 GL in 2004-2005. WS are through VW-flows from high to low water productivity zones (Novo, Garrido, and Varela-Ortega 2009). Higher water productivity (ton/m^3) is reflected in low WF.

During 1996-2005, there were net water losses only in 1998-1999, equivalent to -25 GL. These water losses resulted from the inter-state movement of gram and gram products (-107 GL).

Table 5.9: Crop-wise and year-wise VW-flows embedded in Food Grains (1996-2005)

Year	Crop-wise and year-wise VW-flows embedded in food grains (Giga Litres= GL= X 10^{9} L)									
	Rice in the husk	Rice not in the husk	Wheat	Wheat flour	Gram and gram products	Pulses other than gram	Sorghum and millet	Maize and millet	Other sorts of grains	Total	Appendix for details on year-wise inter-state VW-flows
1996-1997	34	2	975	11	-2	94	0	0	-3	1111	Appendix 34
1997-1998	3	-55	854	111	-15	152	0	0	1	1050	Appendix 35
1998-1999	10	1	-5	56	-107	24	0	-2	-2	-25	Appendix 36
1999-2000	0	-4	-3	11998	-2	3142	0	0	0	15131	Appendix 37
2000-2001	1	-1185	6561	16	-46	-43	-7	-201	-208	4888	Appendix 38
2001-2002	0	-1429	14610	83	-6	-146	46	808	10955	24922	Appendix 39
2002-2003	-482	-1387	4998	1	-18	-172	1962	-124	-173	4606	Appendix 40
2003-2004	49	-2992	18555	6	-10	-68	26	-33	-313	15222	Appendix 41
2004-2005	50	-2251	24734	7	155	-196	48	8	-224	22330	Appendix 42
Total	-335	-9300	71279	12289	-51	2787	2075	456	10033	89235	
WS (max)	50	2	24734	11998	155	3142	1962	808	10955	24922	
Water losses (max)	-482	-2992	-5	1	-107	-196	-7	-201	-313	-25	

Among the food grains, maximum WS were through wheat (24734 GL in 2004-05), wheat flour (11998 GL in 1999-2000), and other sorts of grains (10955 GL in 2001-2002). In contrast, maximum water losses were through rice not in the husk (-2992 GL in 2003-2004), rice in the husk (-482 GL in 2002-2003), and other sorts of grains (-313 GL in 2003-2004).

5.2.1.2. OILSEEDS

There were net water losses of -2124 GL due to the inter-state movement of oilseed during 1996-2005 (Table 5.10). Highest net water losses were -3612 GL in the year 2004-2005, followed by -74 GL in the year 2000-2001. In both the years, water losses resulted from the inter-state VW-flows embedded in oil cakes, i.e. -3556 GL in 2004-2005 and -186 GL in 2001-2002. During 1996-2005, highest net WS were 473 GL in 2001-2002. These WS resulted from the inter-state movement of oilseeds of cotton (281 GL).

Among the categories of oilseeds considered, maximum WS were through other vegetable oil (573 GL in 2004-05), and oilseeds of cotton (448 GL in 1999-2000). It is interesting to note that there were no water losses from the inter-state movement of oilseeds of cotton. Maximum water losses were due to inter-state movement of oil cakes (-3556 GL in 2004-2005), and groundnut oil (-551 GL in 2004-2005).

Table 5.10: Crop-wise and year-wise VW-flows embedded in oilseeds (1996-2005)

Year	Crop-wise and year-wise VW-flows embedded in oilseeds(Giga Litres= GL= X 10^9 L)								
	Oilseeds cotton	**Oilseeds other than cotton**	**Ground nut oil**	**Mustard oil**	**Castor oil**	**Other vegetable oil**	**Oil cakes**	**Total**	**Appendix** for details on year-wise inter-state VW-flows
1996-1997	3	-1	0	-4	2	-2	-27	-29	Appendix 43
1997-1998	9	-5	-2	-2	0	1	201	202	Appendix 44
1998-1999	22	-16	0	-35	0	-11	39	-1	Appendix 45
1999-2000	448	19	-3	-5	-2	8	-228	236	Appendix 46
2000-2001	148	1	-66	-4	0	33	-186	-74	Appendix 47
2001-2002	281	7	-3	-3	0	161	31	473	Appendix 48
2002-2003	166	7	-102	4	0	310	36	422	Appendix 49
2003-2004	93	1	-98	8	0	531	-275	260	Appendix 50
2004-2005	160	15	-551	-253	0	573	-3556	-3612	Appendix 51
Total	1329	28	-826	-293	-1	1604	-3965	-2124	
WS (max)	448	19	0	8	2	573	201	473	
Water losses (max)		-16	-551	-253	-2	-11	-3556	-3612	

5.2.2. National Level (2005-2014)

5.2.2.1. Food Grains

WS through food grains increased from 89235 GL in the post-reforms period (1996-2005) to 207452974 GL in the period of recovery up to 2014 (2005-2014) (Table 5.9 and Table 5.11). During 2005-2014, highest WS were 109.51 PL[23], in 2011-2012, followed by 97.89 GL in 2012-2013. These WS resulted from VW-flows embedded in rice not in the husk, 105.81 PL, in 2011-2012, and wheat, 97.88 PL in 2012-2013 (Table 5.11). In fact, 2011-2012 was the year with the highest production of food grains, 259.32 million tonnes. About 242.23 million tonnes of it was cereals and 17.09 million tonnes was pulses (Government of India 2014a). It is interesting to note that while in 1996-2005, highest water savings were through VW-flows embedded in wheat, in 2005-2014 it is due to rice not in the husk followed by wheat.

During 2005-2014, there were net water losses of -504 GL in the year 2007-2008. Interestingly, highest water losses were also due to VW-flows embedded in the inter-state movement of rice not in the husk. It is crucial to emphasize here that in the year 2007-2008, NFSM was introduced for rice, wheat, and pulses (Government of India 2007a). While in 1996-2005, highest water losses were through gram and gram products, in 2005-2014, it was through rice not in the husk .

Among the food grains, highest WS resulted from inter-state movement of rice not in the husk (105.81PL in 2011-12), followed by wheat (97.88 PL in 2012-13), and pulses other than gram (3.68 PL in 2011-12). Highest water losses were through rice not in the husk (-4485 GL in 2007-08), followed by maize and millets (-954 GL in 2010-11), and pulses other than gram (-296 GL in 2012-2013). There were no water losses due to the inter-state movement of wheat, and sorghum and millet.

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[23] 1 PL = 10^6 GL

Table 5.11: Crop-wise and year-wise VW-flows embedded in Food Grains (2005-2014)

Year	Crop-wise and year-wise VW-flows embedded in food grains (Giga Litres= GL= X 10^9 L)										
	Rice in the husk	**Rice not in the husk**	**Wheat**	**Wheat flour**	**Gram and gram products**	**Pulses other than gram**	**Sorghum and millet**	**Maize and millet**	**Other sorts of grains**	**Total**	**Appendix** for details on year-wise inter-state VW-flows
2005-2006	219	2248	12871	-5	-11	-49	22	-209	150	15237	Appendix 52
2006-2007	16	-332	6609	5	164	52	24	-35	158	6660	Appendix 53
2007-2008	46	-4485	4566	1	142	-106	30	-680	-17	-504	Appendix 54
2008-2009	19	-4325	10504	1	83	-58	53	97	0	6372	Appendix 55
2009-2010	17	1943	10175	-3	49	-153	102	-383	595	12343	Appendix 56
2010-2011	28	673	3501	2	13	-227	65	-954	92	3194	Appendix 57
2011-2012	-1	105811625	9816	2	28	3688770	82	-715	35	109509642	Appendix 58
2012-2013	44	1950	97885464	-2	64	-296	26	-307	83	97887026	Appendix 59
2013-2014	27	2090	11297	0	6	-122	12	-593	286	13004	Appendix 60
Total	415	105811387	97954803	1	538	3687811	416	-3779	1382	207452974	
WS (max)	219	105811625	97885464	5	164	3688770	102	97	595	109509642	
Water losses (max)	-1	-4485		-5	-11	-296		-954	-17	-504	

5.2.2.2. OILSEEDS

While there were net water losses of -2124 GL in 1996-2005, there were net WS of 84504 GL in 2005-2014 embedded in the inter-state movement of oilseeds (Table 5.10, and Table 5.12). During 2005-2014, highest net WS were 59522 GL in the year 2010-2011, followed by 5789 GL in the year 2013-2014. In these two years, WS resulted from the inter-state VW-flows embedded in other vegetable oil, i.e. 59497 GL in 2010-2011 and 4523 GL in 2013-2014. Interestingly, in none of the year during 2005-2014, there were net water losses (Table 5.12).

During the period selected for VW-flows assessment, highest production of oilseeds was 32.479 million tonnes in 2010-11. This was attributed to favorable weather conditions and support from Government of India to the oilseeds production and developmental programmes and policies which resulted in higher yield (Government of India 2012c). From the VW-flows assessment of oilseeds, it is evident that the maximum WS were through other vegetable oil (59497 GL in 2010-2011), and groundnut oil (1323 GL in 2005-2006). It is interesting to note that there were no water losses due to the inter-state movement of other vegetable oil. In contrast, maximum water losses were through oilseeds other than cotton (-2756 GL in 2012-2013), and mustard oil (-1048 GL in 2005-2006).

Table 5.12: Crop-wise and year-wise VW-flows embedded in oilseeds (2005-2014)

Year	Crop-wise and year-wise VW-flows embedded in oilseeds(Giga Litres= GL= X 10 ^{9} L)								
	Oilseeds cotton	**Oilseeds other than cotton**	**Ground nut oil**	**Mustard oil**	**Castor oil**	**Other vegetable oil**	**Oil cakes**	**Total**	**Appendix** for details on year-wise inter-state VW-flows
2005-2006	-66	-114	-88	-1048	-1	4185	1323	4192	Appendix 61
2006-2007	-58	-128	-145	16	0	1443	262	1390	Appendix 62
2007-2008	-65	261	-246	-22	3	932	382	1244	Appendix 63
2008-2009	-69	74	1593	93	-1	1110	637	3437	Appendix 64
2009-2010	-77	184	-48	-163	3	4499	-72	4327	Appendix **65**
2010-2011	102	229	3	-163	0	59497	-146	59522	Appendix 66
2011-2012	-50	408	0	143	0	4166	-728	3939	Appendix 67
2012-2013	-5	-2756	0	-151	-1	2883	694	664	Appendix 68
2013-2014	-4	959	-5	-42	0	4523	359	5789	Appendix 69
Total	-292	-883	1063	-1335	4	83237	2710	84504	
WS (max)	102	959	1593	143	3	59497	1323	59522	
Water losses (max)	-77	-2756	-246	-1048	-1		-728		

Although net water losses are reflected only in few years at the national level, larger unsustainable VW-flows are visible at the sub-national scale which are discussed in the next section.

5.2.3. ZONE/STATE LEVEL (1996-2005)

5.2.3.1. FOOD GRAINS

During the post-reforms period, North zone experienced highest water losses, i.e., equivalent of -19.8 TL/yr[24] te VW- exports from the zone embedded in food grains. In contrast, West and South zones had the highest (11.1 TL/yr), and second highest (9.7 TL/yr) WS, respectively (Figure 5.1). Major VW-imports of West and South zones are from North. There are also VW-flows from relatively water plenty East and North-East zones to water-scarce South and North zones, respectively (Figure 4.8 and Figure 5.1).These are the sustainable flows as they lead to the distribution of water scarcity.

[24] 1 TL = 10^3 GL; (1PL = 1 Peta Litre = 10^3TL= 10^6GL = 10^9ML = 10^{12}KL = 10^{15}L)

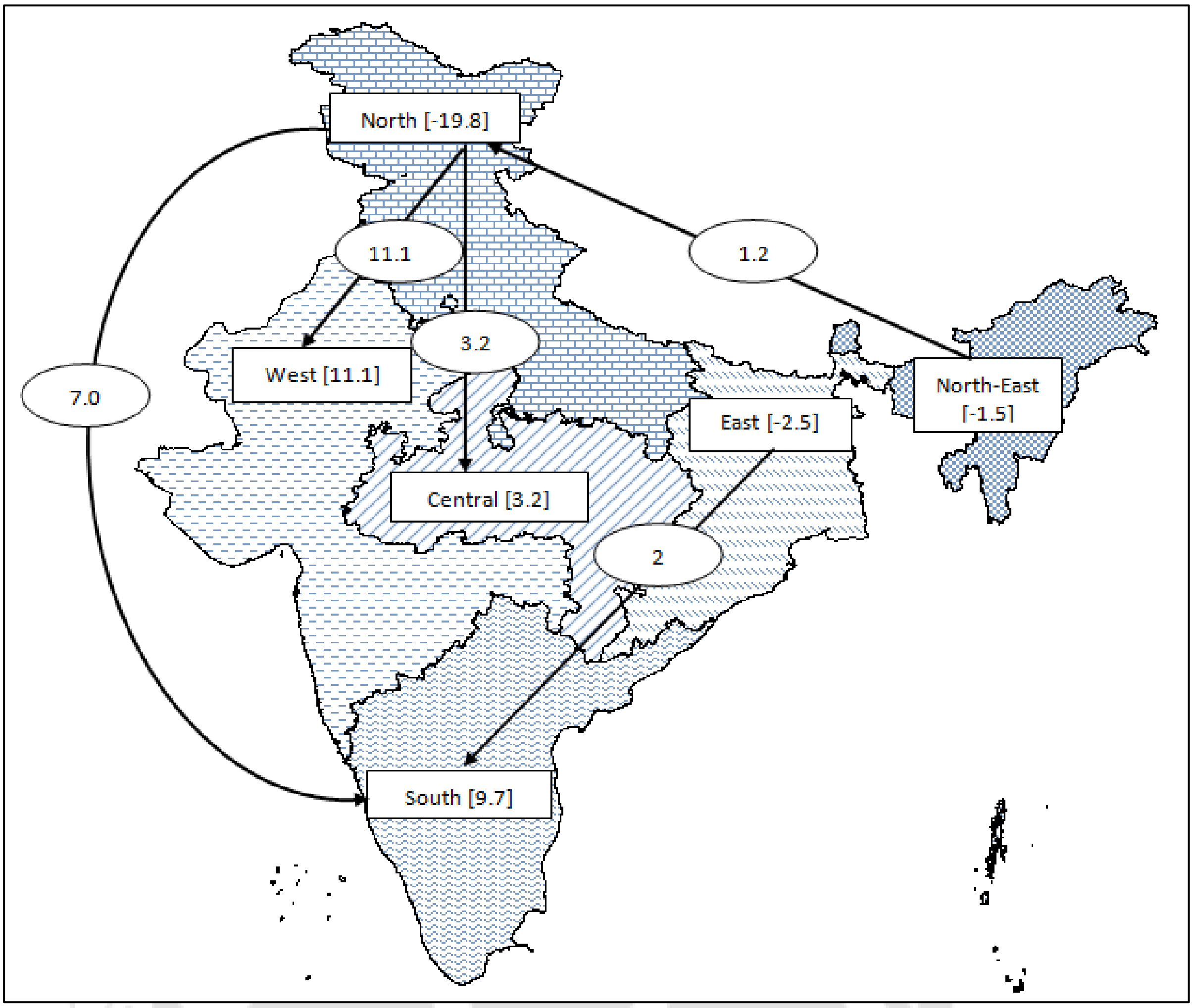

Figure 5.1: Zone-wise VW flows embedded in food grains (1996-2005)
Values in boxes are net VW-exports (water losses indicated by negative sign), or VW-imports (WS). Values in circles indicate major flows between zones (TL/yr)

Sustainable VW-flows during 1996-2005 resulted in water saving in highly and moderate to highly water-scarce states like Gujarat, Maharashtra, and Rajasthan of West zone, and Andhra Pradesh, Karnataka, and Tamil Nadu of South zone (Figure 4.8, and Figure 5.2). In contrast, unsustainable VW-flows led to water losses in highly and moderately to highly water-scarce states, such as Delhi, Haryana, Himachal Pradesh, Punjab, and Uttar Pradesh of North zone (Figure 4.8, and Figure 5.2).

Maharashtra had highest WS (3.724 TL/yr), while Punjab had highest water losses (-4.589 TL/yr) (Figure 5.2). It is crucial to emphasize here that, among the states with water savings only Karnataka and Maharashtra implemented SWPs in the post-reforms period, i.e., in 2002 and 2003 respectively. These states are at the forefront of institutional reforms for sustainable water use. They aim to enhance agriculture productivity and WUE through an integrated approach to land and water use policies (Government of Maharashtra 2003, Government of Karnataka 2002).

Among the water losing states, only Uttar Pradesh implemented SWP in the post-reforms period, i.e., in 1999. The SWP of Uttar Pradesh has two important insights in the context of water scarcity, and water losses due to unsustainable VW-flows during 1996-2005. These are that the SWP acknowledges water as a scarce resource, this is significant because the state is classified as moderately to highly water-scarce (Figure 4.8) (Government of Uttar Pradesh 1999). Second, the SWP emphasizes on minimization of water loss in crop production, this is crucial as Uttar Pradesh has the second highest water losses embedded in the inter-state movement of food grains (Figure 5.2) (Government of Uttar Pradesh 1999).

There is a concern over mitigation of water scarcity in Punjab as there has been intensive food grains' production, since 1960's to meet national food requirements without a state-specific water policy (Figure 4.8).

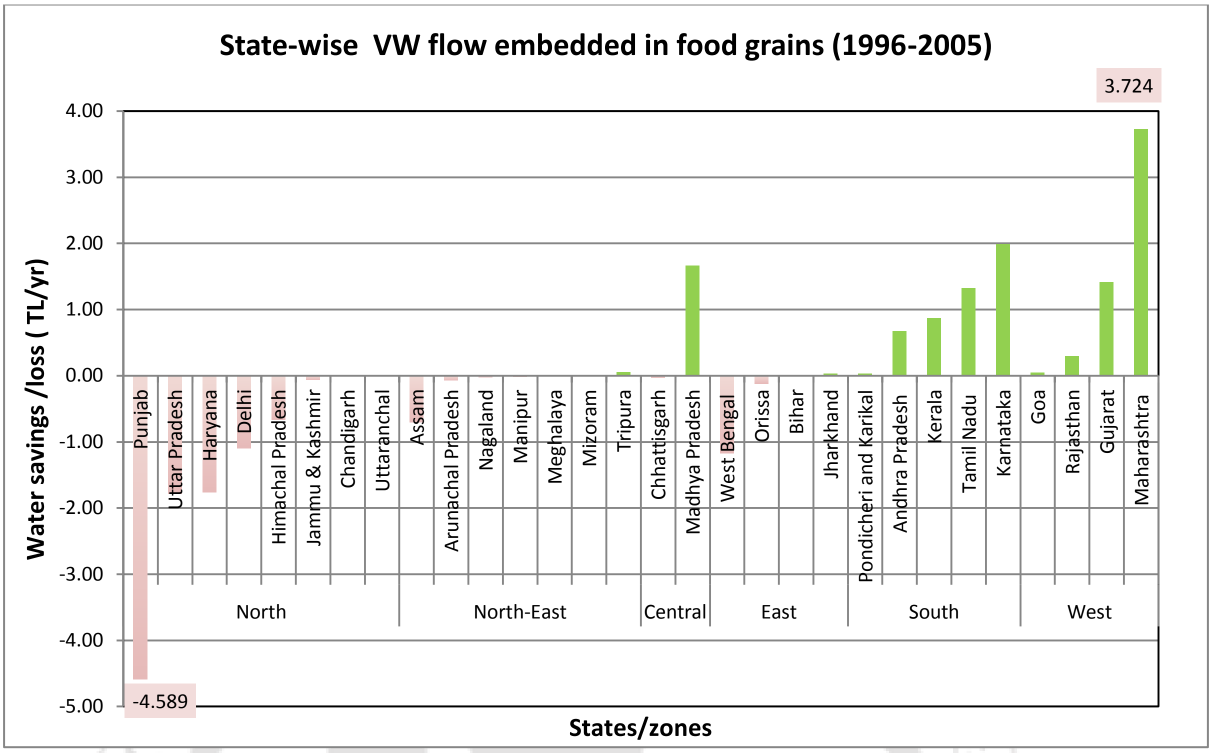

Figure 5.2: State-wise VW flows embedded in food grains (1996-2005)

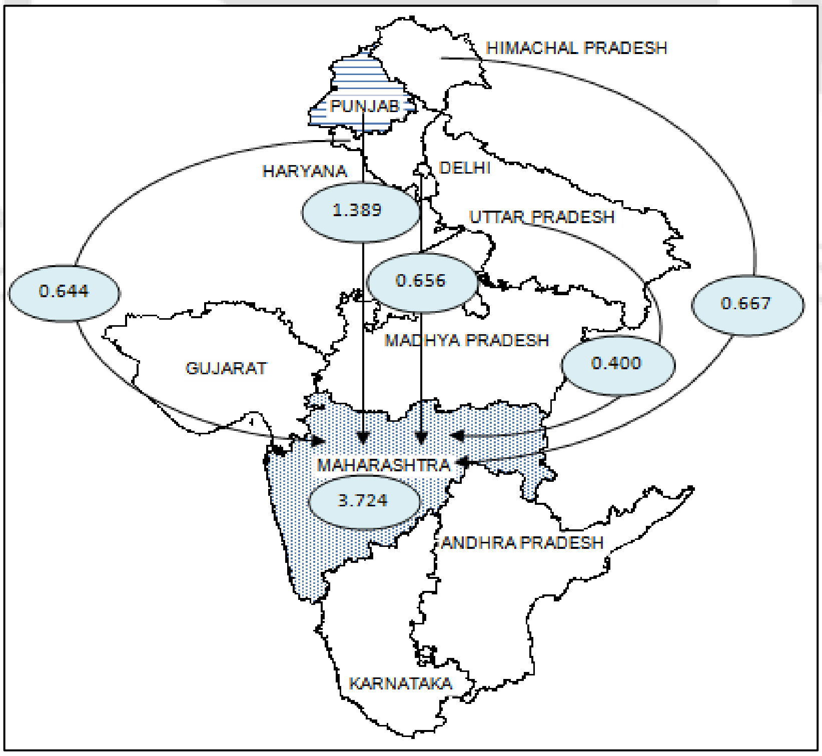

Figure 5.3: Five major inflows to Maharashtra, state with highest WS during Five major inflows to Maharashtra, state with highest WS during 1996-2005 (in TL/yr)

Maharashtra is a net VW-importer despite being a major producer of food grains (Table 3.2 and Figure 4.8). This is primarily because Maharashtra figures as the second most populous state of India (Government of India 2012b). This reflects that high VW-imports are driven by food requirements of a large population. Among the states from which Maharashtra received VW-inflows, are Punjab and Haryana which are highly water-scarce while Maharashtra is moderate to highly water-scarce (Katyaini and Barua 2016) (Table 5.3, and Figure 4.8). As there are VW-flows from highly water-scarce states of Punjab and Haryana, there is a concern of the sustainable use of scarce water resources of Punjab and Haryana.

Punjab was, in fact, the largest VW-exporter because Punjab was considered as a part of highly productive zone based on the regionally differentiated strategy of ninth Five Year Plan (1997-2002) (Government of India 2008b). The classification of zoning was based on agro-climatic and environmental conditions, in order to increase agriculture production. However, this classification did not consider the sustainability of water use. As a result, North-West zone comprising of Punjab, Haryana, was classified as high productivity zone. The zone is characterized by high irrigation-low rainfall and has become highly water-scarce due to unsustainable VW-outflows.

VW-outflows from Punjab are to highly populous states of India (Government of India 2012b). Punjab is supporting the food security of highly populous states at the expense of its scarce water resources. Further, VW-flows from Punjab to Gujarat and Andhra Pradesh reflect VW-flows from a highly water-scarce state to other highly water-scarce states (Katyaini and Barua 2016) (Figure 5.4, and Figure 4.8). These flows are not leading to the distribution of water scarcity, and it can be inferred that production and inter-state movement of food grains are not aligned with the relative water endowments.

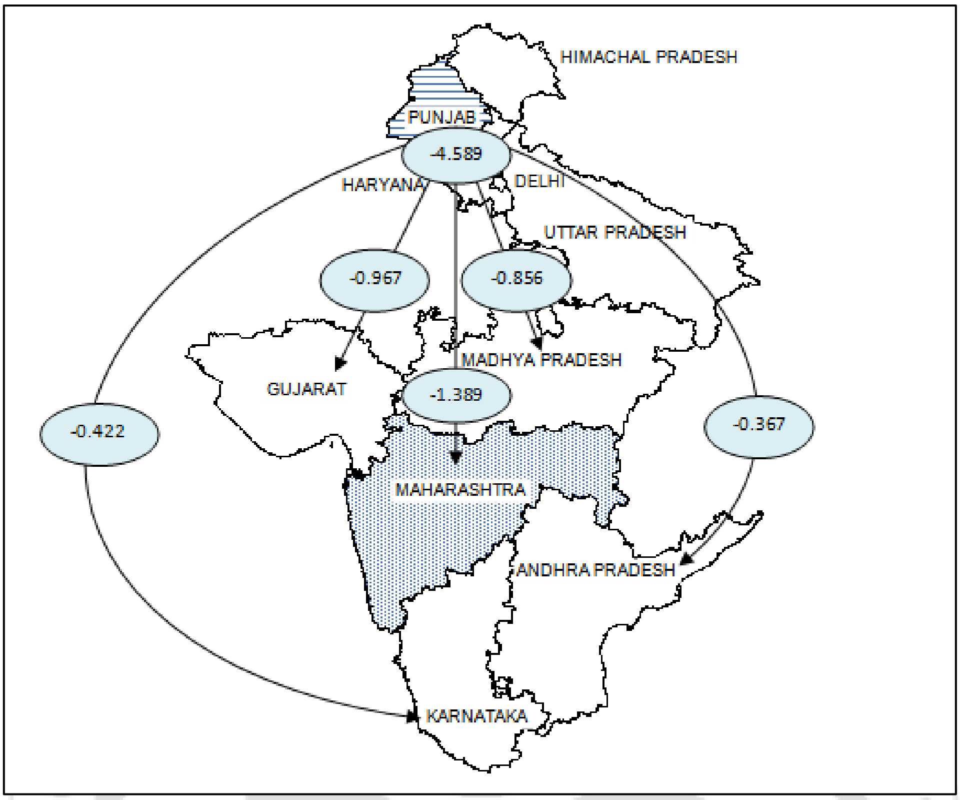

Figure 5.4: Five major VW outflows from Punjab, state with highest water losses during 1996-2005 (in TL/yr)

5.2.3.2. OILSEEDS

Among the zones of India, South has the highest water losses (-27.9 GL/yr), while North has highest WS (34.7 GL/yr) as a result of inter-state movement of oilseeds (Figure 5.5). In fact, North, West and Central zones are the only zones which have WS while other zones have water losses. The sustainable VW-flows are from relatively water plenty North-East and East to water-scarce North zone and from relatively water plenty East to water-scarce West zone (Figure 4.8 and Figure 5.5).

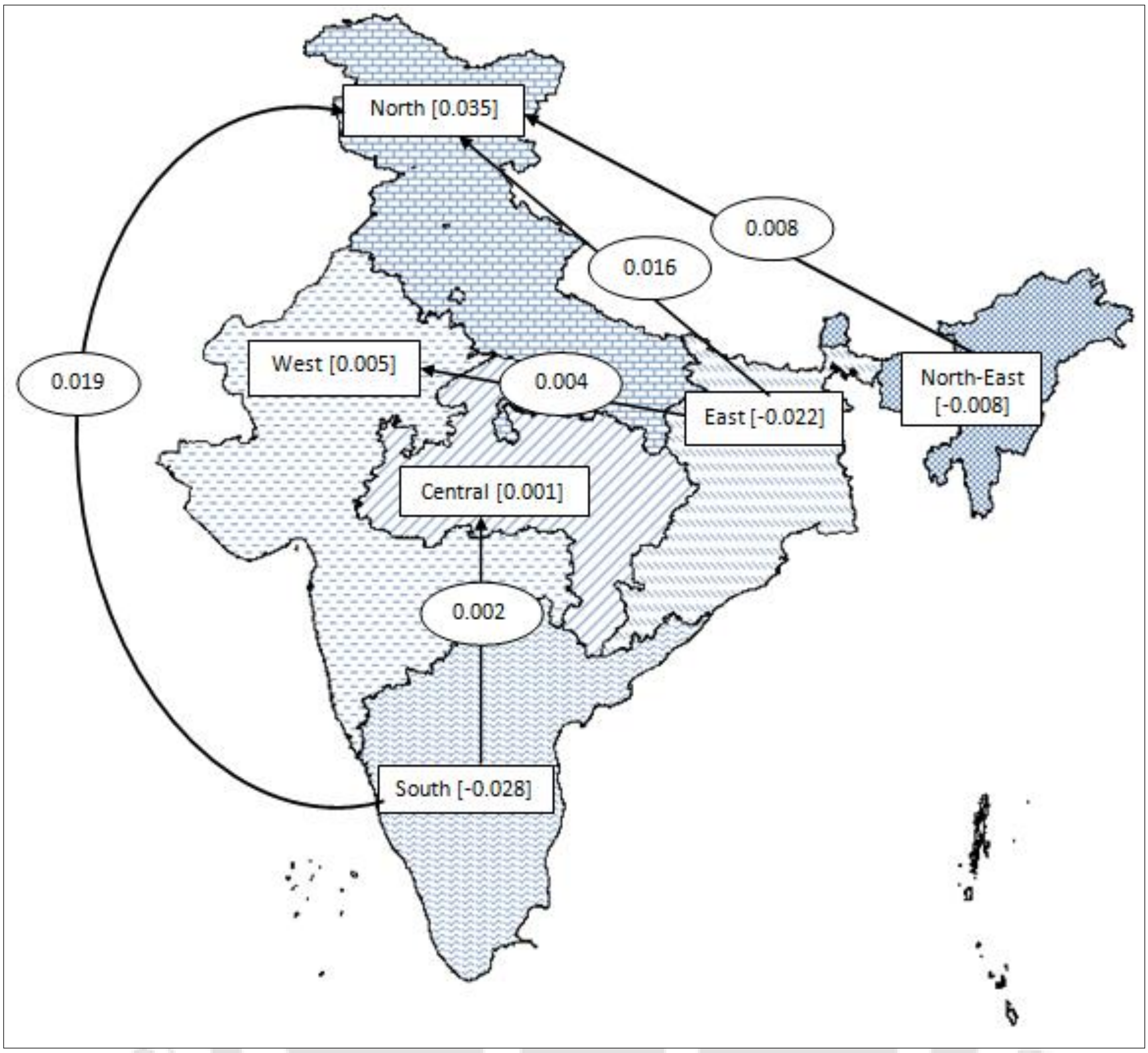

Figure 5.5: Zone-wise VW flows embedded in oilseeds (1996-2005)
Values in boxes are net VW exports (water losses indicated by negative sign), or imports (WS). Values in circles indicate major flows between zones (TL/yr)

At the state level, Andhra Pradesh faces highest water losses (-0.266 TL/yr), while Uttar Pradesh has the highest WS (0.251 TL/yr) (Figure 5.6). During the post-reforms period, Uttar Pradesh (1999), Karnataka (2002), Maharashtra (2003), Rajasthan (1999)[25], and Chhattisgarh (2001) are among the WS states which have formulated and implemented an SWP during the post-reforms period (Figure 5.6 and Table 3.6). In contrast, none of the states with water losses have formulated an SWP (Figure 5.6 and Table 3.6). The concern of aggravation of water scarcity is associated with Andhra Pradesh, as it is a major producer of oilseeds, has the

[25] Rajasthan SWP, 1999 could not be accessed

highest water losses through export of oilseeds to the rest of India, despite high water scarcity. In addition, Andhra Pradesh did not formulate and implement an SWP to manage and regulate its water resources during 1996-2005 (Figure 4.8, Figure 5.6, and Table 3.6).

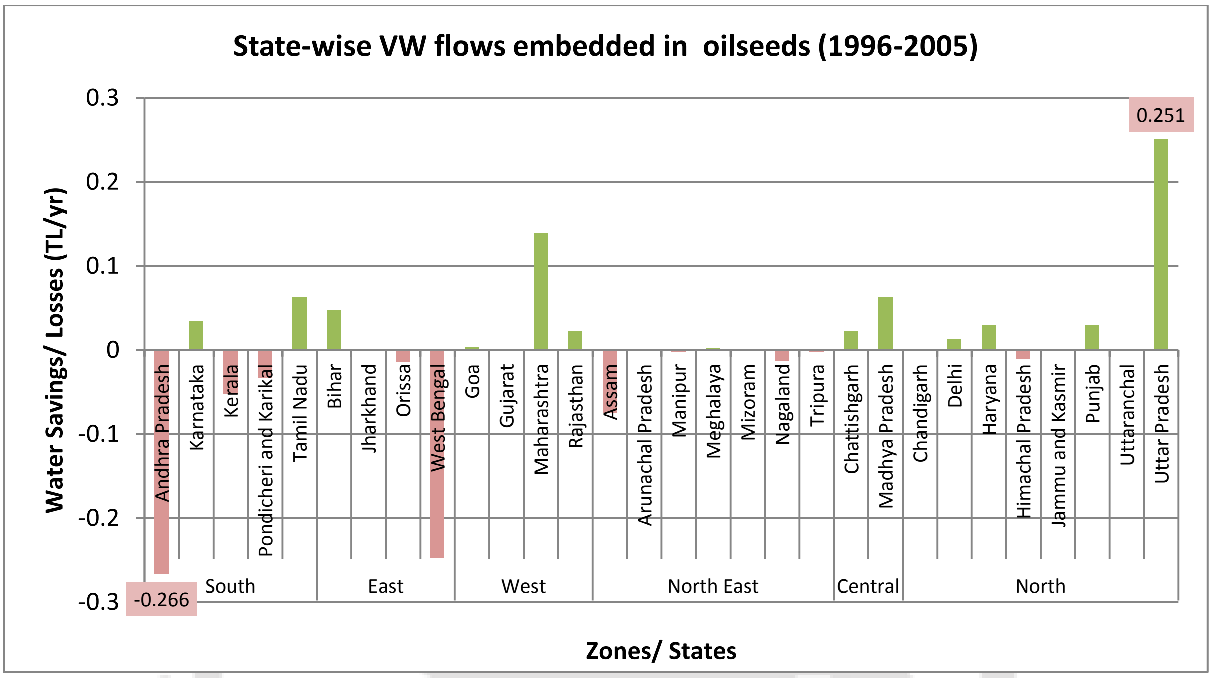

Figure 5.6: State-wise VW flows embedded in oilseeds (1996-2005)

The five states from which Uttar Pradesh received largest VW-inflows are Kerala, and Pondicherry[26] from South zone; West Bengal from East; and Assam and Nagaland states from North-East zone (Figure 5.6, and Figure 5.7). These VW-flows are sustainable because they are from relatively water-rich to water-scarce state. The major VW-outflows from Andhra Pradesh, which has the highest water losses, are to Haryana, Delhi, Maharashtra, Chhattisgarh, and Madhya Pradesh (Figure 5.6, and Figure 5.8). The VW-flows are unsustainable as they are from the highly water-scarce state, Andhra Pradesh, to highly, moderate to highly, and moderately water-scarce states (Figure 4.8).

[26] Pondicherry: is now known as Puducherry

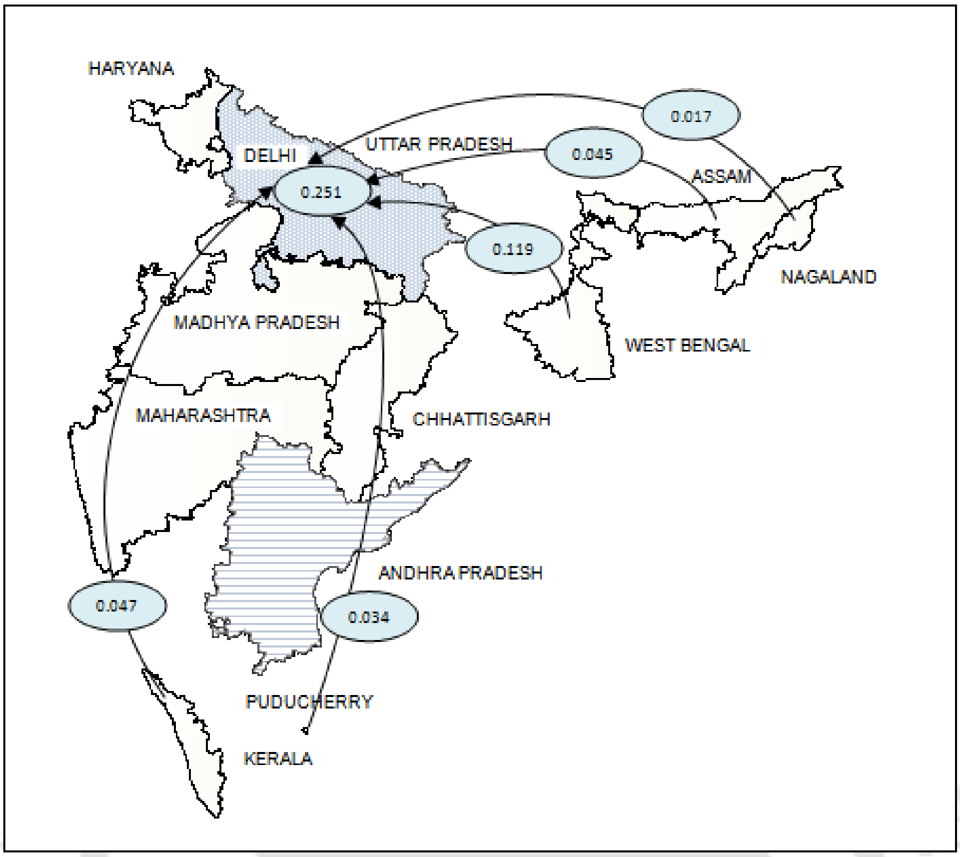

Figure 5.7: Five major VW inflows to Uttar Pradesh which contributes to highest water savings during 1996-2005 (in TL/yr)

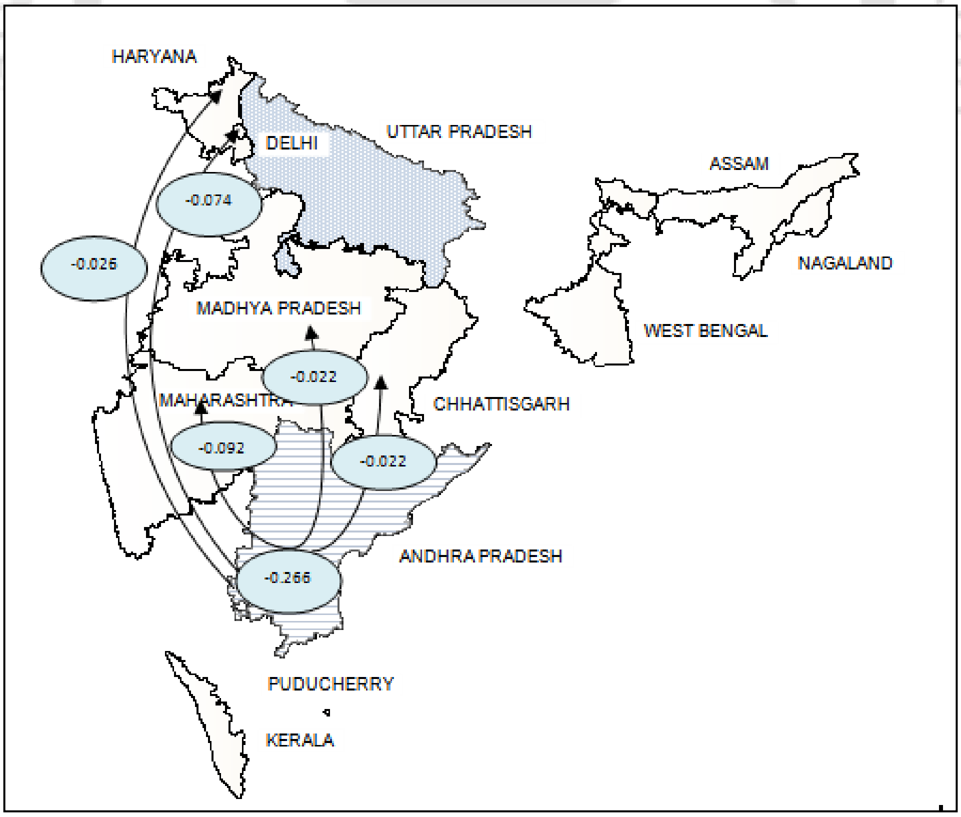

Figure 5.8: Five major VW outflows from Andhra Pradesh which contributes to highest water losses during 1996-2005 (in TL/yr)

The next section deals with the aggregated VW-flows embedded in the inter-state movement of food grains and oilseeds in the post reforms period (1996-2005).

5.2.3.3. AGGREGATE: FOOD GRAINS AND OILSEEDS

Aggregation of the VW-flows embedded in food grains and oilseeds at state level reveals that VW-flows embedded in food grains are much larger than oilseeds during 1996-2005. Punjab had highest net water losses (-4.589 TL/yr) and Maharashtra (3.863 TL/yr) had highest net WS (Figure 5.9).

The next section dwells upon the VW-flows during the period of 2005-2014.

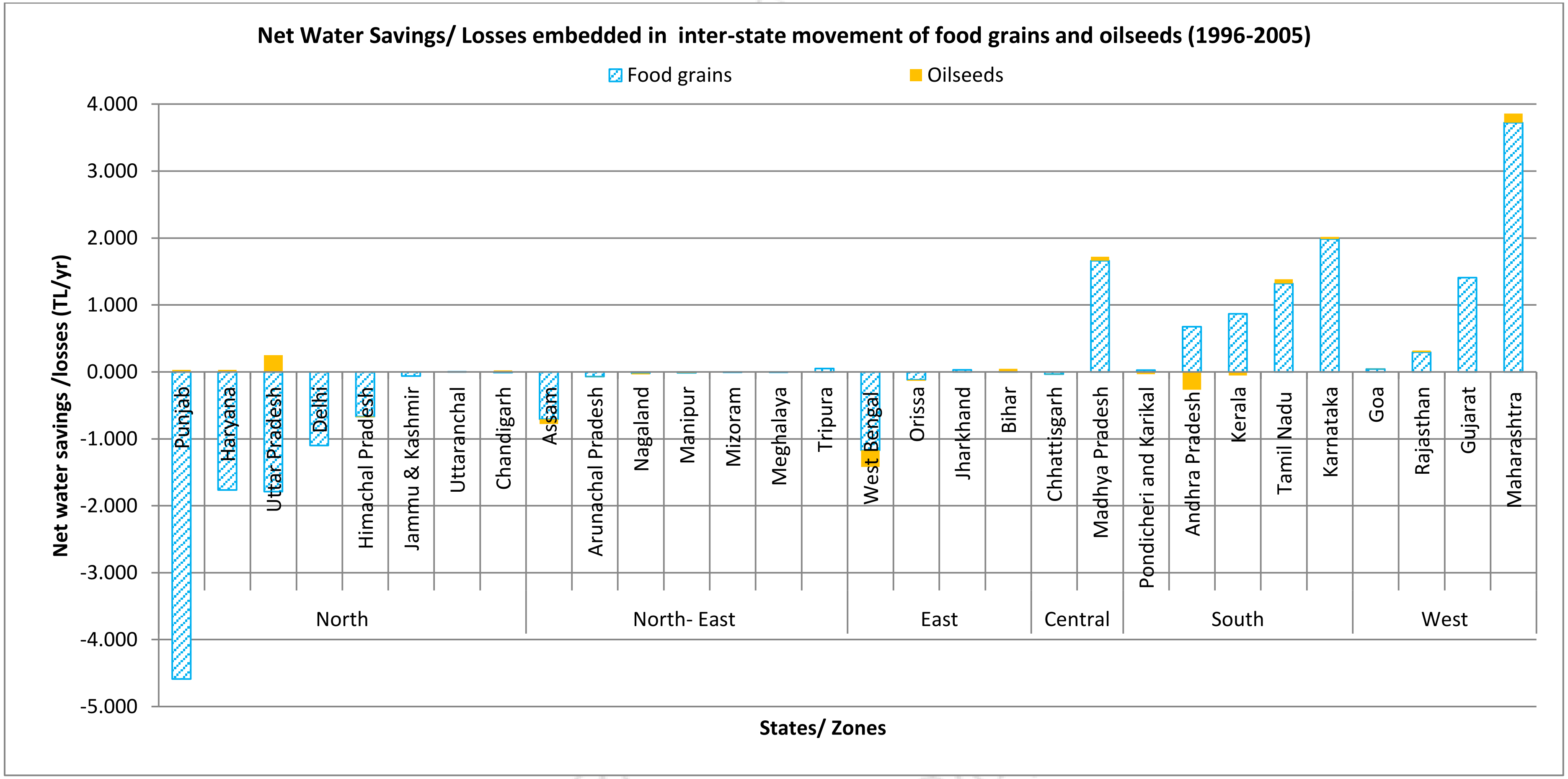

Figure 5.9: Net Water Savings /Losses embedded in inter-state movement of food grains and oilseeds (1996-2005)

5.2.4. Zone/State Level (2005-2014)

5.2.4.1. Food Grains

North zone continues to have the highest water losses, i.e.,-16.2 PL/yr. The water losses of North zone have increased from 1996-2005 to 2005-2014. There were sustainable VW-flows from water plenty North-East to water-scarce North in 1996-2005 which have reversed in 2005-2014, i.e., the VW-flows are from North to North-East in 2005-2014 (Figure 5.1, and Figure 5.10). There is another striking finding, i.e., reversal of flow from Central zone in 2005-2014 as it became a VW-exporter to South. As a result, Central zone, which had WS of 3.2 TL/yr during 1996-2005, accrued water losses of -11.7 PL/ yr during 2005-2014 (Figure 5.1, and Figure 5.10).

South and West zones continue to have highest WS, which is 11.1PL/yr, and 10.8PL/yr, respectively (Figure 5.10). In comparison to 1996-2005 South has surpassed West in WS. It is important to emphasize here that the quantum of WS and losses during 2005-2014 are much higher than the 1996-2005 because of increase in inter-state movement of food grains (Figure 5.1, and Figure 5.10).

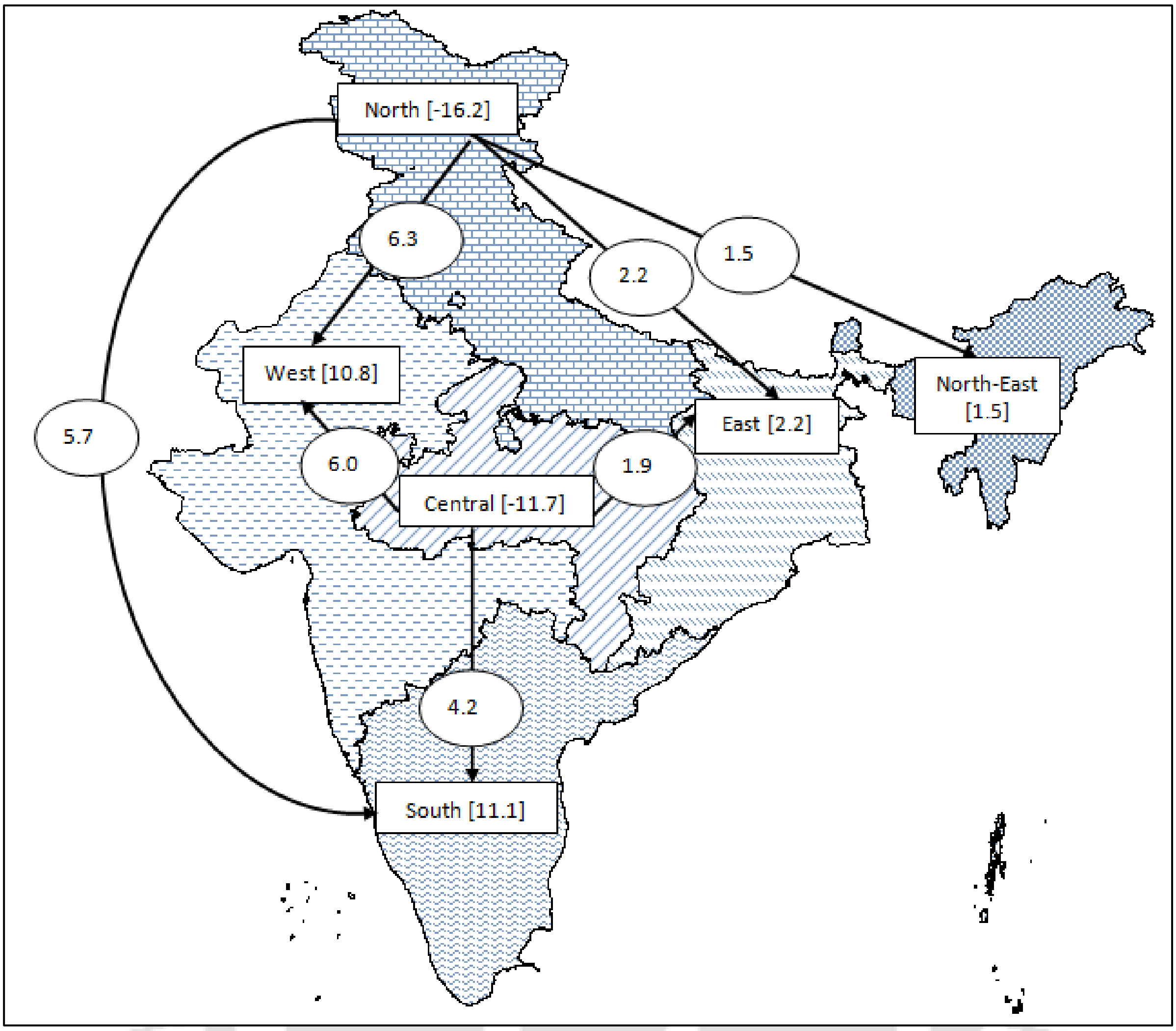

Figure 5.10: Zone-wise VW flows embedded in food grains (2005-2014)

VW-flows assessment at state level reveals that Punjab continues to face highest water losses (-5.982 PL/yr). This can be attributed to poor governance of its water use due to the absence of a state-specific water policy. The absence of a SWP for Punjab has crippled water resources management and governance in Punjab. Even though a draft SWP was formulated for Punjab in 2008 it has not been accepted yet. Quantum of water losses has increased from-4.589 TL/yr in 1996-2005 to-5.982 PL/yr in 2005-2014 (Figure 5.2, and Figure 5.11). Concerns are also associated with other highly water-scarce states, such as Haryana, Rajasthan and Andhra Pradesh which experience water losses due to VW-outflows through food grains (Figure 4.8, and Figure 5.11).

WS in Maharashtra has increased from 3.724 TL/yr in 1996-2005 to 3.694PL/yr in 2005-2014. However, Tamil Nadu has highest WS during the 2005-2014 (period of recovery), i.e., 4.398 PL/yr. Both Maharashtra and Tamil Nadu are at the forefront of water resources management as Maharashtra continues to govern its water resources through SWP, 2003 while Tamil Nadu implemented SWP in 2007. Revision of SWP of Maharashtra and Tamil Nadu was being discussed during 2005-2014 (Government of Tamil Nadu 2013, Press Trust of India 2013). A periodic revision of SWP is important to strengthen the institutional arrangements for regulation and management of water use.

In addition to Maharashtra and Tamil Nadu, the WS states which have an SWP are Uttar Pradesh (1999), Goa (2000), Karnataka (2002), Himachal Pradesh (2005), Orissa (2007), Kerala (2008), and Jharkhand (2011) (Figure 5.11 and Table 3.6). The states with water losses, which have a SWP are Andhra Pradesh (2008), Madhya Pradesh (2005), Rajasthan (2010), and Chhattisgarh (2011 and Draft SWP,2012).

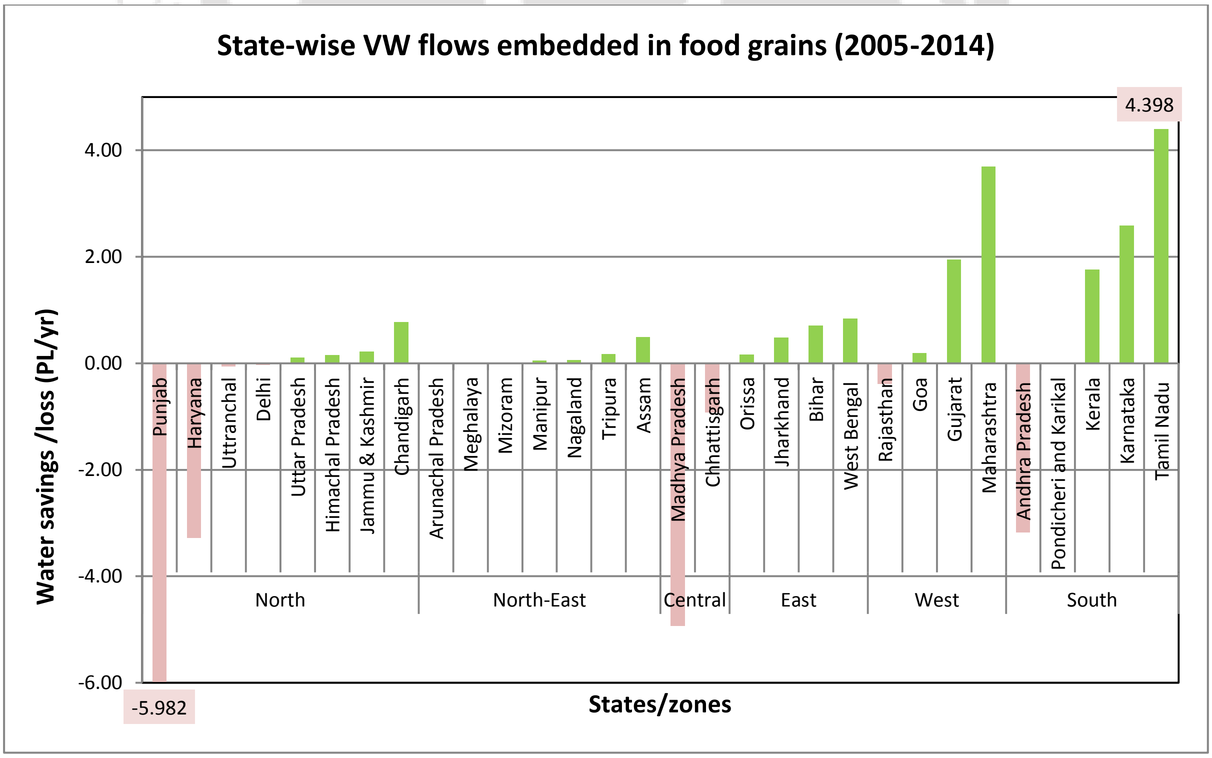

Figure 5.11: State-wise VW-flows embedded in food grains (2005-2014)

Among the states from where Tamil Nadu receives highest VW- inflows, Rajasthan, Punjab and Andhra Pradesh are major producers of food grains despite high water scarcity (Table 3.2, Figure 4.8, and Figure 5.12).This is because these states have large arable land, and in India, arable land and yield are the main criteria for decisions on production (Katyaini and Barua 2016, Government of India 2015d, 1997). Although the water resources were considered important in development planning since first NWP (1987), water scarcity is being considered for the first time in current Five Year Plan (2012-2017) (Government of India 2013b).

Only Punjab does not have an SWP among the five states from where Tamil Nadu receives major VW-inflows. This reflects a weak institutional arrangement in Punjab leading to highest water losses in both the periods considered for assessment. Highly water-scarce Punjab losses water embedded in food grains to relatively water plenty state, Assam (Figure 4.8, and Figure 5.13). Besides Assam and Tamil Nadu, major VW-outflows from Punjab are to moderate to highly water-scarce Karnataka and Maharashtra, and highly water-scarce Gujarat (Figure 5.13) (Katyaini and Barua 2016). It can also be inferred that the inter-state VW-flows are not leading to the distribution of water scarcity and are unsustainable. Interestingly, these states have relatively larger population than Punjab. Therefore, food demand for a larger population is the driver of VW- imports (Government of India 2012b).

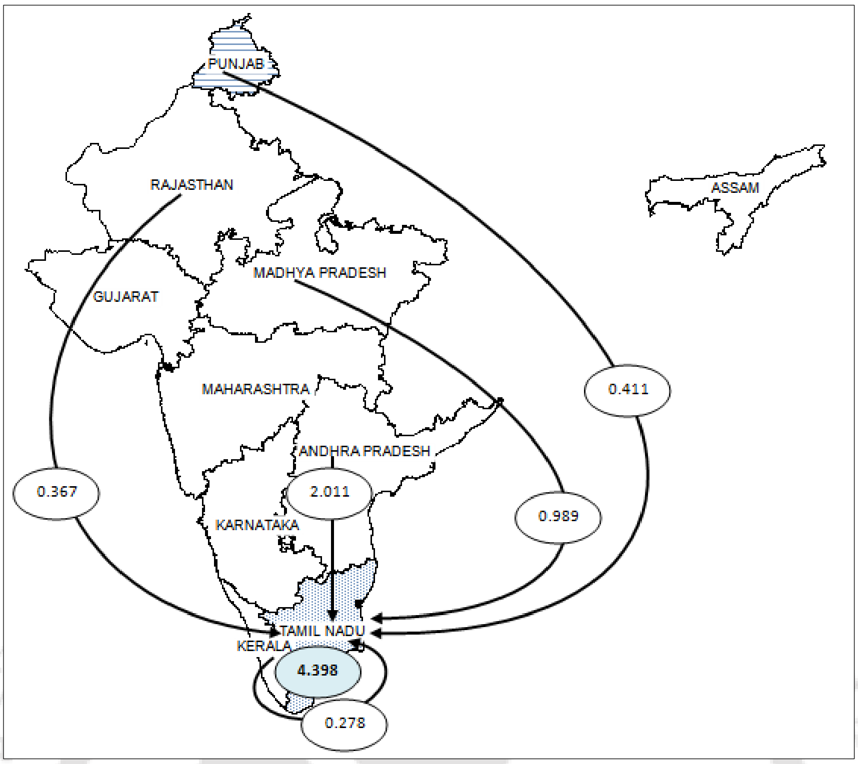

Figure 5.12: Five major VW- inflows to Tamil Nadu which contributes to highest WS during 2005-2014 (in PL/yr)

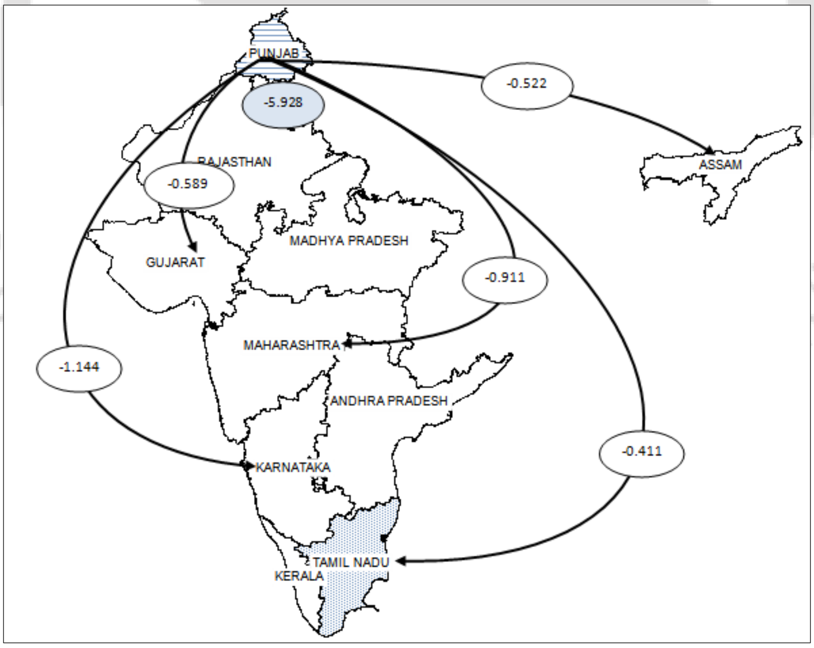

Figure 5.13: Five major VW-outflows from Punjab which contributes to highest water losses during 2005-2014 (in PL/yr)

5.2.4.2. OILSEEDS

South zone continues to have the highest water losses, i.e.-0.587 TL/yr due to the inter-state movement of oilseeds during 2005-2014. West zone emerged to have the highest WS in

2005-2014, i.e. 3.421 TL/yr, while in 1996-2005, North zone had the highest WS, 0.035 TL/yr (Figure 5.14, and Figure 5.5). Similar to food grains the magnitude of water losses and WS is higher in the period of recovery as compared to the post-reforms period. This is because of increase in inter-state movement of oilseeds.

There are several variations in VW-flows embedded in oilseeds during 2005-2014, in comparison to 1996-2005. These are sustainable VW-flows were from water plenty North-East zone to water-scarce North in 1996-2005, however, in 2005-2014 it is to water-scarce South in 2005-2014 (Figure 4.8, and Figure 5.14). While West was importing VW embedded in oilseeds from East during 1996-2005, it is importing VW from Central zone during 2005-2014. As these flows are from relatively water plenty to water-scarce zones they are sustainable VW-flows.

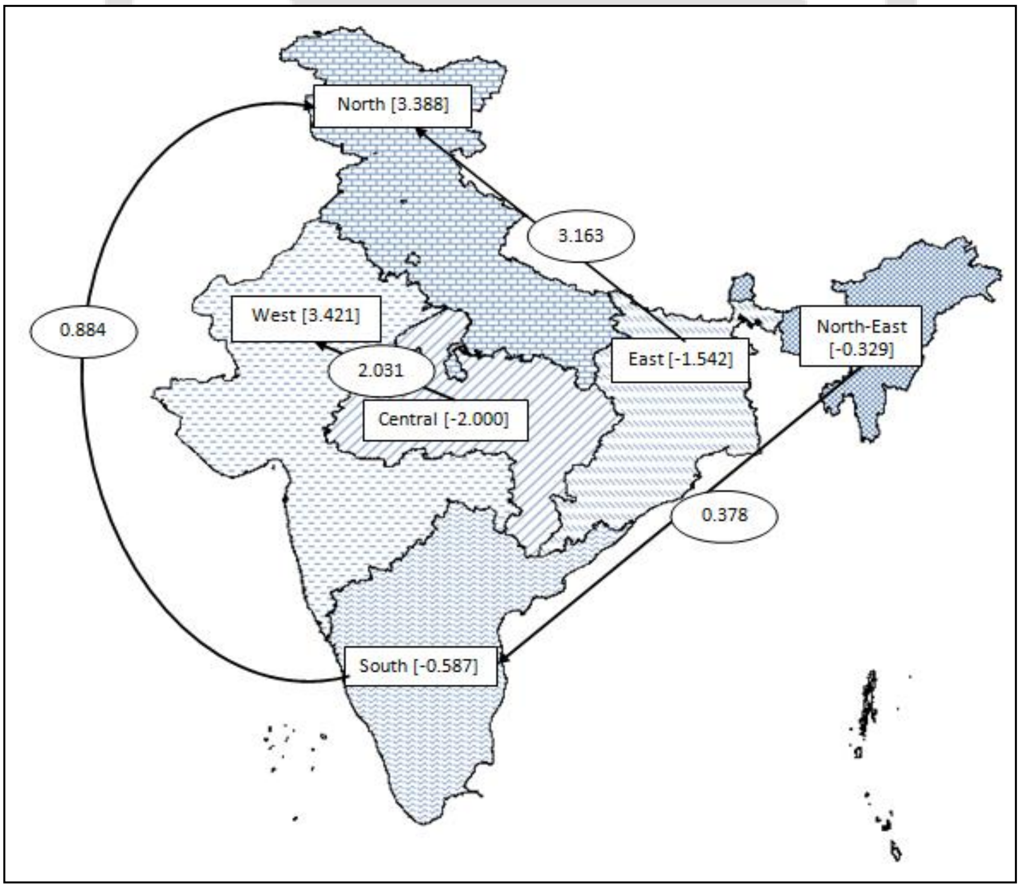

Figure 5.14: Zone-wise VW flows embedded in oilseeds (2005-2014)
Values in boxes are net VW-exports (water losses indicated by negative sign), or VW-imports (WS). Values in circles indicate major flows between zones (TL/yr)

At the state level, West Bengal has the highest water losses, i.e.,-6.788 TL/yr, while Bihar has the highest WS, i.e., 3.616TL/yr (Figure 5.15). Andhra Pradesh, which had the highest water losses in 1996-2005, is among the highest water losing states in 2005-2014, even though it has formulated and implemented an SWP in 2008 (Figure 5.6, and Figure 5.15). Uttar Pradesh, which was the highest WS state in 1996-2005, has higher WS in 2005-2014 (3.118 TL/yr) than in 1996-2005 (0.251 TL/yr) (Figure 5.6, and Figure 5.15).

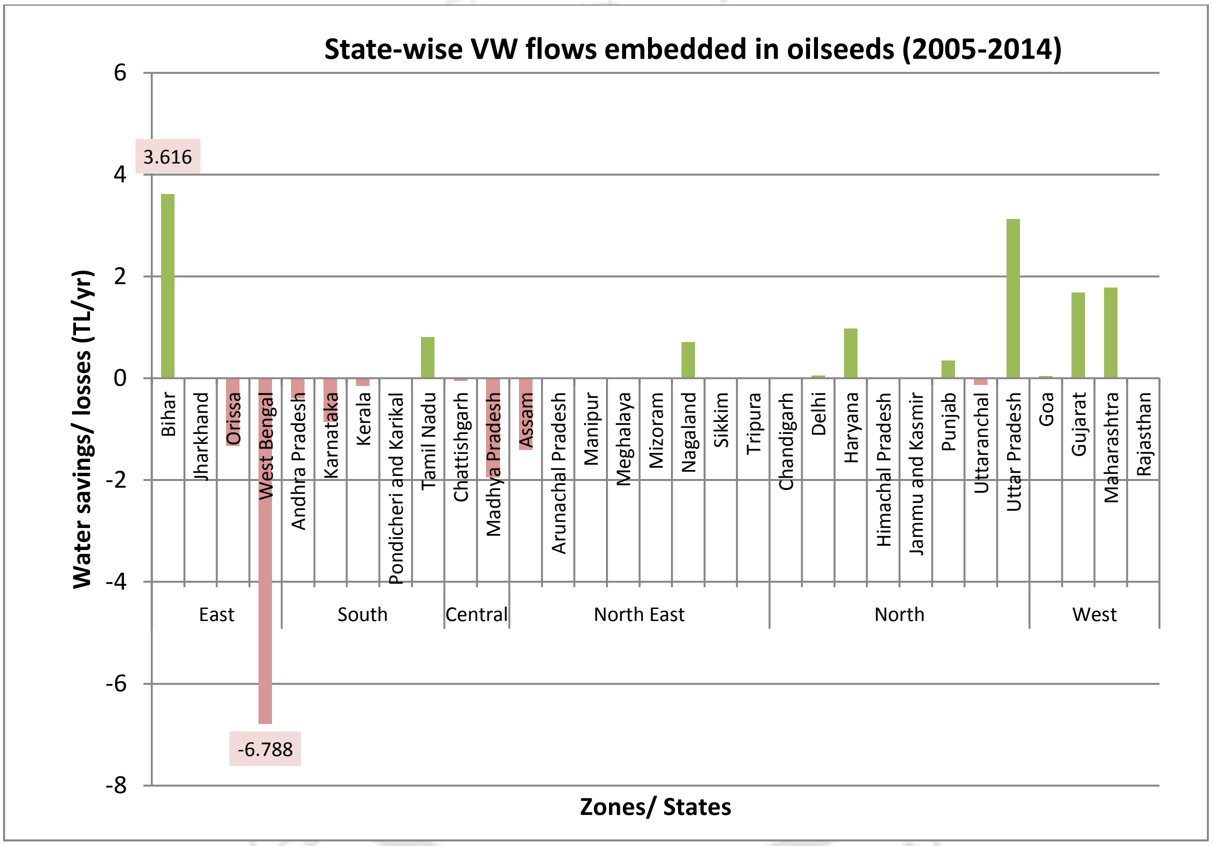

Figure 5.15: State-wise VW flows embedded in oilseeds (2005-2014)

Uttar Pradesh (1999), Goa (2000), Maharashtra (2003), and Himachal Pradesh (2005) were the WS states which have implemented respective SWPs. Karnataka (2002), Madhya Pradesh (2005), Orissa (2007), Andhra Pradesh (2008), Kerala (2008), Rajasthan (2010), and Jharkhand (2011) are the water losing states which have implemented SWPs. Water losses from Andhra Pradesh and Rajasthan are a concern as these are highly water-scarce (Figure 4.8, and Figure 5.15).

The five major VW-outflows from West Bengal are to Bihar in the East, Uttar Pradesh in the North, Nagaland in the North-East, Madhya Pradesh in the Central, and Maharashtra in the West zone (Figure 5.16).These VW-flows are from moderate to highly water-scarce West Bengal to relatively water plenty states. Maharashtra is an exception as it is moderately to highly water-scarce state like West Bengal (Figure 4.8).

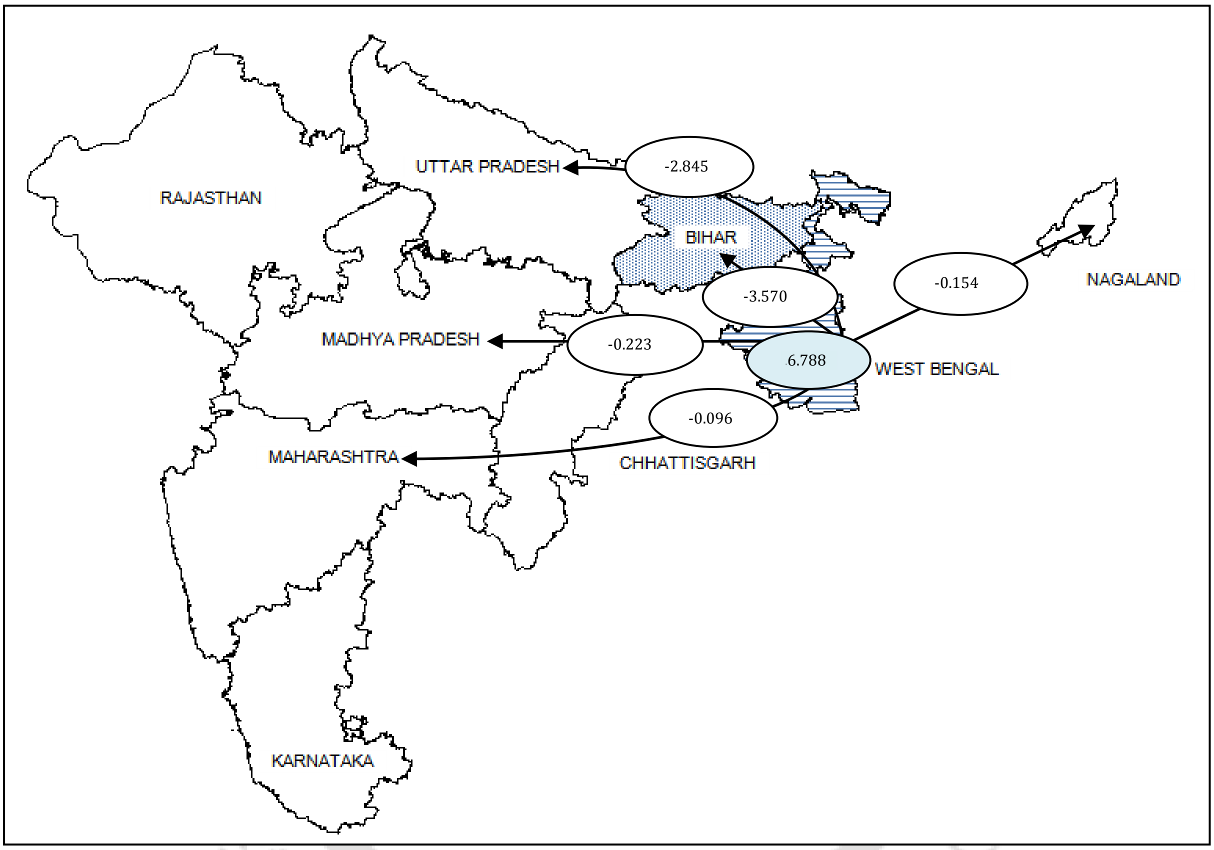

Figure 5.16: Five major VW outflows from West Bengal which contributes to highest water losses during 2005-2014 (in TL/yr)

The five major net VW-inflows to Bihar, the highest WS state, are from West Bengal, Madhya Pradesh, Karnataka, Rajasthan, and Chhattisgarh (Figure 5.17). Among these flows, concerns are associated with the unsustainable VW-flows from highly water-scarce Rajasthan, and moderately to highly water-scarce Karnataka and West Bengal to moderately water-scarce Bihar (Figure 4.8).

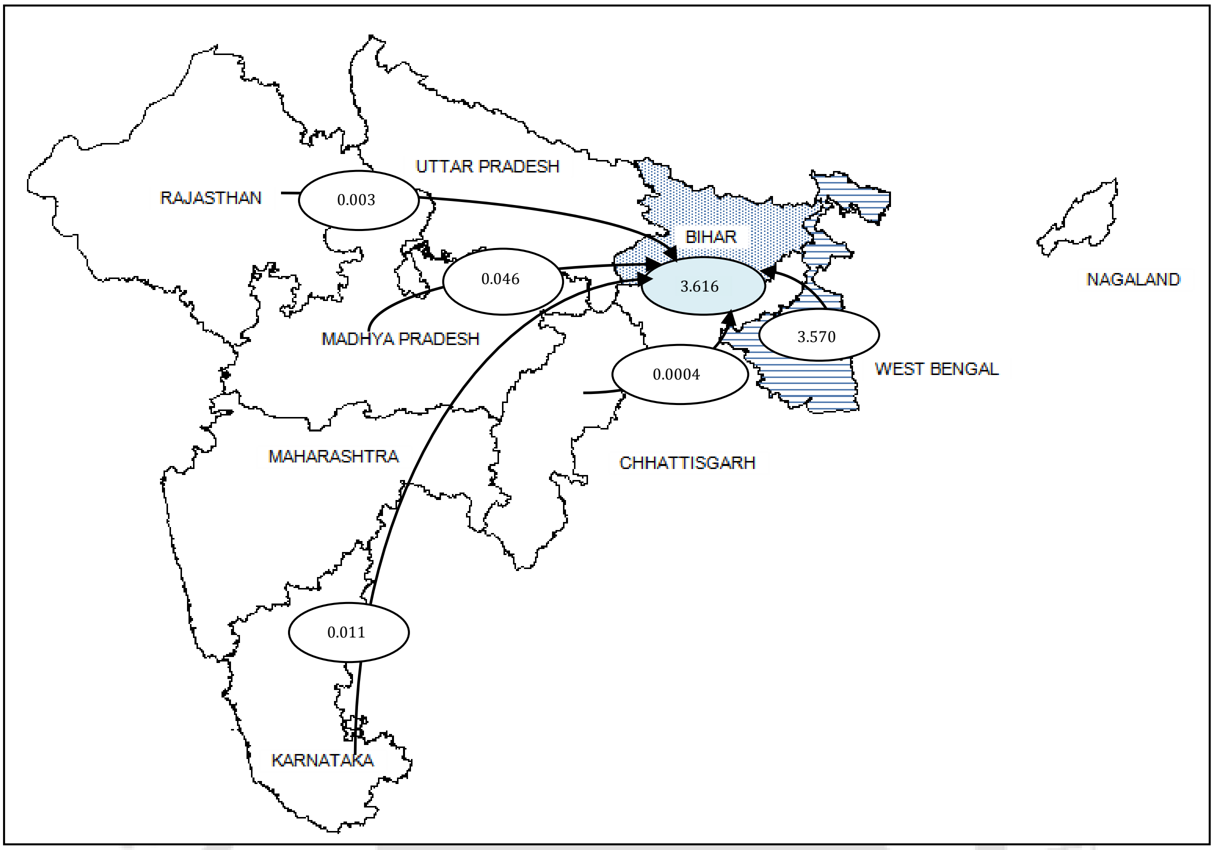

Figure 5.17: Five major VW inflows to Bihar which contributes to highest water savings during 2005-2014 (in TL/yr)

The next segment is on the aggregate of inter-state VW-flows embedded in food grains and oilseeds during 2005-2014.

5.2.4.3. AGGREGATE: FOOD GRAINS AND OILSEEDS

Similar to 1996-2005, aggregation of the VW-flows embedded in food grains and oilseeds for the period of 2005-2014, reveal that VW-flows embedded in food grains are much larger than oilseeds. Punjab continues to have highest net water losses and is a concern as despite high water scarcity, there has been a tremendous increase in water losses of Punjab, i.e., from -4.589 TL/yr in 1996-2005 to -5982TL/yr in 2005-2014 (Figure 5.9, and Figure 5.18). The highest net water savings are of Tamil Nadu, 4399 TL/yr in 2005-2014 while in 1996-2005 it was of Maharashtra. Maharashtra has the second highest water savings in 2005-2014, net water savings increased from 3.863 TL/yr in 1996-2005 to 3696 TL/yr in 2005-2014(Figure 5.9, and Figure 5.18).

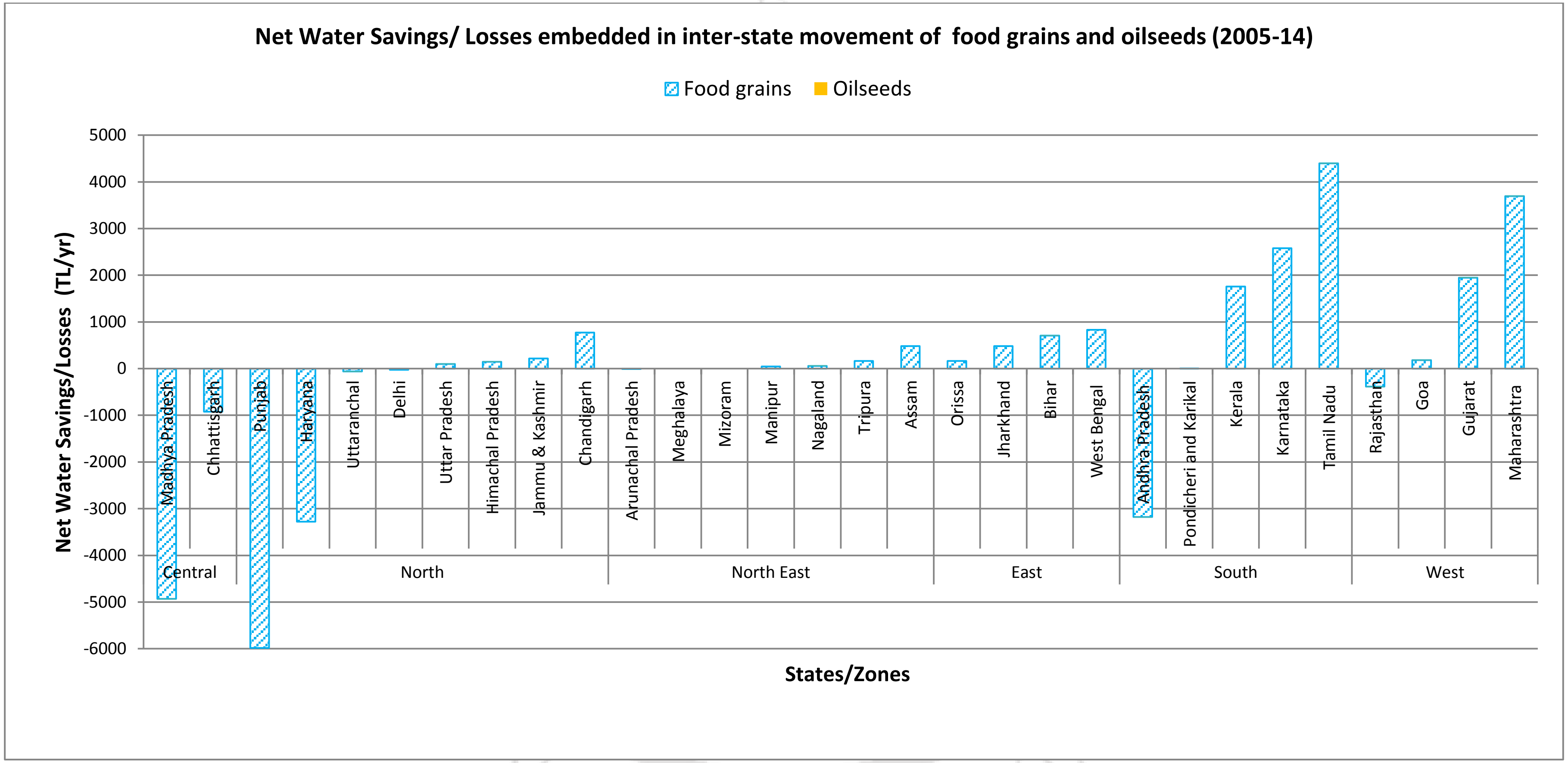

Figure 5.18: Net Water Savings/Losses embedded in inter-state movement of food grains and oilseeds (2005-2014)

5.2.5.SUMMING UP

Aggregating the VW-flows embedded in food grains and oilseeds revealed whether a state is a net VW importer or exporter in the two periods (Figure 5.9, and Figure 5.18). The VW-assessment at the state level is important to identify important concerns associated with water scarcity and its mitigation through appropriate policy measures.

There is a concern of the sustainable use of scarce water resources associated with the VW-exporters which experience high (Punjab, Haryana, and Delhi), and moderate to high (Uttaranchal) water scarcity and have not yet formulated and implemented state-specific water policies. There is also a concern of integration of relevant scientific knowledge on water scarcity and policy measures to mitigate it in SWP of highly (Andhra Pradesh, and Rajasthan), and moderately (Chattisgarh, and Madhya Pradesh) water-scarce states which are net VW-exporters.

The concern associated with net VW-importers, which are highly (Gujarat), moderate to highly (Jammu and Kashmir), and modertately (Bihar, and West Bengal) water-scarce states, and lack a state-specific water policy is of food security, in addition to water security as they depend on VW-imports to meet their food requirements. There is also a concern of integration of relevant scientific knowledge on water scarcity and policy measures to mitigate it in SWP of highly (Tamil Nadu), moderately to highly (Himachal Pradesh, Karnataka, Maharashtra, and Uttar Pradesh), and moderately (Jharkhand and Orissa) water-scarce states which are net VW- importers.

The next chapter deals with these concerns through a critical analysis of national and state water policies in the context of science-policy interface to identify the challenges and opportunities to mitigate water scarcity in India.

Chapter 6 WATER POLICY AT SCIENCE-POLICY INTERFACE: CHALLENGES AND OPPORTUNITIES TO MITIGATE WATER SCARCITY IN INDIA[27]

This chapter is an outcome of the third research question, which aims to examine the science-policy interface at the national and state level in the context of water scarcity. The chapter is based on the water scarcity assessment (discussed in Chapter 4) and VW-flows (discussed in Chapter 5). The discussion here puts the outcome of VW-flows assessment of food grains and oilseeds in the larger context of mitigation of water scarcity through strengthening science-policy interface in water policies of India. The chapter begins with a discussion on national water policy followed by a critical analysis of the state water policies to identify key challenges and opportunities. The discussion emphasizes on the significance of integrating VW- flows assessment in water policies to strengthen the science- policy interface for mitigation of water scarcity.

6.1. NATIONAL WATER POLICY

Water scarcity was identified as a key issue in the first NWP (Government of India 1987). It continues to be a persistent challenge for the water sector even in the latest NWP (Government of India 2002a, 2012d). The first NWP also established the importance of water in development planning, which is hampered by water scarcity.

Policy emphasis on sustainability came through NWP, 2002. A weak science-policy interface is reflected in the lag in policy recognition of sustainability which emerged as a key concern at International Conference on Water and Environment (ICWE), 1992; however it was recognized in water policy a decade later in 2002. Further, NWP (2002) emphasis on

[27] Sections of this chapter have been published in Water Policy journal in 2016 entitled '*Water Policy at science-policy interface - challenges and opportunities for India*'

sustainability was limited to physical and financial dimension, i.e., economic sustainability. It took a decade to revisit the second NWP, i.e., in 2012 in order to integrate all the three dimensions of sustainability in the context of water use to mitigate persistent water scarcity. For instance, NWP (2012), in addition to the emphasis on physical and financial sustainability, recognized the impacts of climate change on water resources, and the importance of water sustainability for food security. Further, it prescribes sustainable production and consumption through a sustainable use of water in the economy, and changing lifestyles, respectively. It recognizes the significance of 'meeting ecological needs of rivers' and indicates the need for scientific research on the determination of e-flows. It also emphasizes a need to raise awareness of the 'economic value' of water to reduce inefficiency and water scarcity. These policy directions indicate recognition of environmental sustainability. Further, NWP 2012 is the first water policy which has been formulated through a participatory approach (Government of India, 1987, 2002, 2012). A participatory approach to policy-making reflects social sustainability. However, concerns associated with ecology for environmental sustainability, and equity and justice for social sustainability, which are considered as major policy concerns, in the context of water, in the scientific community are not adequately covered in the NWPs.

The NWP is a guideline for the states to formulate their own SWP to address state-specific concerns. This is because water is a state subject in India with the role of Central Government limited to resolving inter-state water disputes (Iyer 2007). Hence, the science-policy interface will be examined at the state level in the next section.

6.2. STATE WATER POLICIES

The impetus to formulate SWP was provided by NWP (2002), as it suggested states to formulate SWP within 2 years. During 2002-2012, thirteen states formulated SWPs on the guidelines of NWP (2002) (Table 3.6 and Table 6.1). Orissa, Tamil Nadu, and Uttar Pradesh states were proactive in formulating and implementing their first SWP in 1994, 1994, and 1999, respectively. Among the highly water-scarce states, only three states-Tamil Nadu, Andhra Pradesh, and Rajasthan have implemented their respective SWP (Figure 4.8, and Table 6.1). In contrast, pro-active states like Goa and Kerala despite being low to moderately water-scarce have implemented SWP to manage and sustainably use their water resources. Interestingly, Jharkhand and Chhattisgarh, which are moderately water-scarce and are recently formed states, have also implemented SWPs. In fact, Chhattisgarh was carved out of Madhya Pradesh in the year 2000 and has implemented SWP in 2001.

Finiteness of water resources and an increase in water scarcity has been recognized in all the SWPs except that of Chhattisgarh, primarily because Chhattisgarh faces moderate water scarcity. It is appreciable that Kerala and Goa, which are low to moderately water-scarce, perceive water scarcity as an issue in the future. However, none of the SWPs discuss intensity of water scarcity faced and there is a lack of emphasis on regional variation of water scarcity within the state, for instance, at district and block (*taluk*) level. States with high, and moderate to high water scarcity (Table 6.1), dwell more upon intra-state water scarcity. However, its reference is limited to groundwater availability, quality and rainfall. This kind of underrepresentation in states experiencing moderate to high and high water scarcity can have adverse consequences on water sustainability. Further, water scarcity is discussed only in the context of approach I[28], i.e., based on 'human water requirements' in the policy discourse. For instance, even the latest SWPs like that of Rajasthan (2010), refers to only Falkenmark Index, 1989 while discussing water scarcity even though there has been an evolution in the approaches to assess water scarcity (Chapter Chapter 4). This poses a challenge for science-policy interface, as latest scientific knowledge is not recognized in

[28] Approach I: discussed in section 4.1.1

newly formed SWPs. It can be inferred that water scarcity is partially reflected in respective SWPs as latest scientific knowledge is partially integrated.

The science-policy interface in SWPs of states with water savings (net VW-importers) and water losses (net VW-exporters)[29] (Table 6.1), is discussed in this section. It is based on five key indicators - (1) water scarcity inducers; (2) water allocation priorities; (3) water use efficiency; (4) water savings; and (5) stakeholder's participation and water literacy to mitigate water scarcity (criteria for selecting these key indicators is discussed in section 3.3.2). The discussion aims to identify the key challenges and opportunities to strengthen the science-policy interface in the formulation of water policies of states without an SWP, and revision of existing water policies of states with an SWP to mitigate water scarcity.

Table 6.1: Water scarcity levels of net VW importing and exporting states

Water Scarcity levels	**States with water savings (net VW importers)**		**States with water losses (net VW exporters)**	
	Have SWP	**Do not have SWP**	**Have SWP**	**Do not have SWP**
High	Tamil Nadu,2007	Gujarat	Andhra Pradesh,2008 Rajasthan,2010	Delhi Haryana Punjab
Moderate to High	Himachal Pradesh, 2005 Karnataka,2002 Maharashtra,2003 Uttar Pradesh, 1999	Jammu & Kashmir		Uttaranchal
Moderate	Jharkhand, 2011 Orissa,2007	Bihar West Bengal	Chhattisgarh,2001 Madhya Pradesh,2003	
Low to Moderate	Goa,2000 Kerala,2008	Assam Manipur Meghalaya Nagaland Tripura		Arunachal Pradesh Mizoram
The year mentioned next to the state is the year in which SWP was implemented.				

6.2.1. Water Scarcity Inducers

The first indicator of science-policy interface is the inclusion of water scarcity inducers. There are two kinds of water scarcity inducers, *human-induced*, and *climate-driven.* While

[29] Net VW-importers and VW-exporters were identified through VW-flows assessment discussed in Chapter 5

human-induced water scarcity is recognized in SWPs, there is a lack of emphasis on the climate-driven water scarcity. The *human-induced* effects like rising water demand and persistent inefficiencies are most prominent across SWPs. For instance, in the SWPs of highly water-scarce states which are net VW-exporters, Andhra Pradesh (2008), and Rajasthan (2010); highly water-scarce state which is net VW-importer, Tamil Nadu (1994); moderate to highly water-scarce states which are net VW-importers, like Uttar Pradesh (1999), Maharashtra (2003) (Table 6.1). These human-induced effects are attributed to population rise, rapid socio-economic growth, unplanned development, urbanization, industrialization, inefficiencies in agriculture, and pollution in various parts of India. Further, state specific inducers have been identified, e.g., Uttar Pradesh considers hydro and thermal power; Goa and Orissa consider mining; and Kerala considers deforestation and sand mining. While many SWPs recognize water scarcity to be human-induced, only a few consider it to be climate-driven (Falkenmark et al. 2007) .Climate change induces water scarcity not only by affecting the supply but also demand as it increases climate variability and uncertainty. Even with growing scientific evidence and research on impacts of climate change since the 1990s (IPCC n.d.),the latest SWPs do not acknowledge water scarcity as climate-driven, except that of Goa (2000) and Andhra Pradesh (2008). According to the findings of this research, while Goa is a low to moderately water-scarce state and a net VW-importer, Andhra Pradesh is highly water-scarce and a net VW-exporter (Table 6.1).

Although several states with and without SWPs address *climate-driven* water scarcity through State Action Plan on Climate Change (SAPCC)[30], there is concern regarding how the implementation of SAPCC and SWP are coordinated to address *climate-driven* water scarcity adequately. This is because water resources are governed by policies formulated by the

[30] SAPCC is based on the guidelines of National Action Plan on Climate Change (NAPCC) which came in 2008. Water is one of the eight priority themes of National Action Plan on Climate Change (Government of India 2008a)

Ministry of Water Resources, while SAPCC is under the aegis of Ministry of Environment, Forest and Climate Change.

6.2.2. WATER ALLOCATION PRIORITIES

Science-policy interface is reflected in the uses which are prioritized for allocating water in water policies. Here the discussion revolves around prioritization of water use for agriculture, and for meeting water requirements of ecology and environment. The policy emphasis on sustainable use is also examined.

The first NWP (1987) was revised in 2002 with two major modifications in water allocation priorities, i.e., integration of ecology and navigation, and bifurcation of the industrial sector into agro and non-agricultural(Government of India 1987, 2002a). The order of water allocation priorities of NWP 2002 are (1) drinking water, (2) irrigation, (3) hydropower[31], (4) ecology, (5) agro-industries and non-agricultural industries, and (6) navigation and other uses. In India, agriculture and power generation have been prioritized since 1855, when famine brought irrigation into prominence (Figure 6.1). It is also evident in the fact that in 1985, Ministry of Irrigation and Power was renamed as Ministry of Water Resources (MoWR), which appointed a National Water Resources Council to adopt the NWP 1987(Government of India 2015b).

[31] Chhattisgarh is the only state which has not recognized hydropower as a water allocation priority.

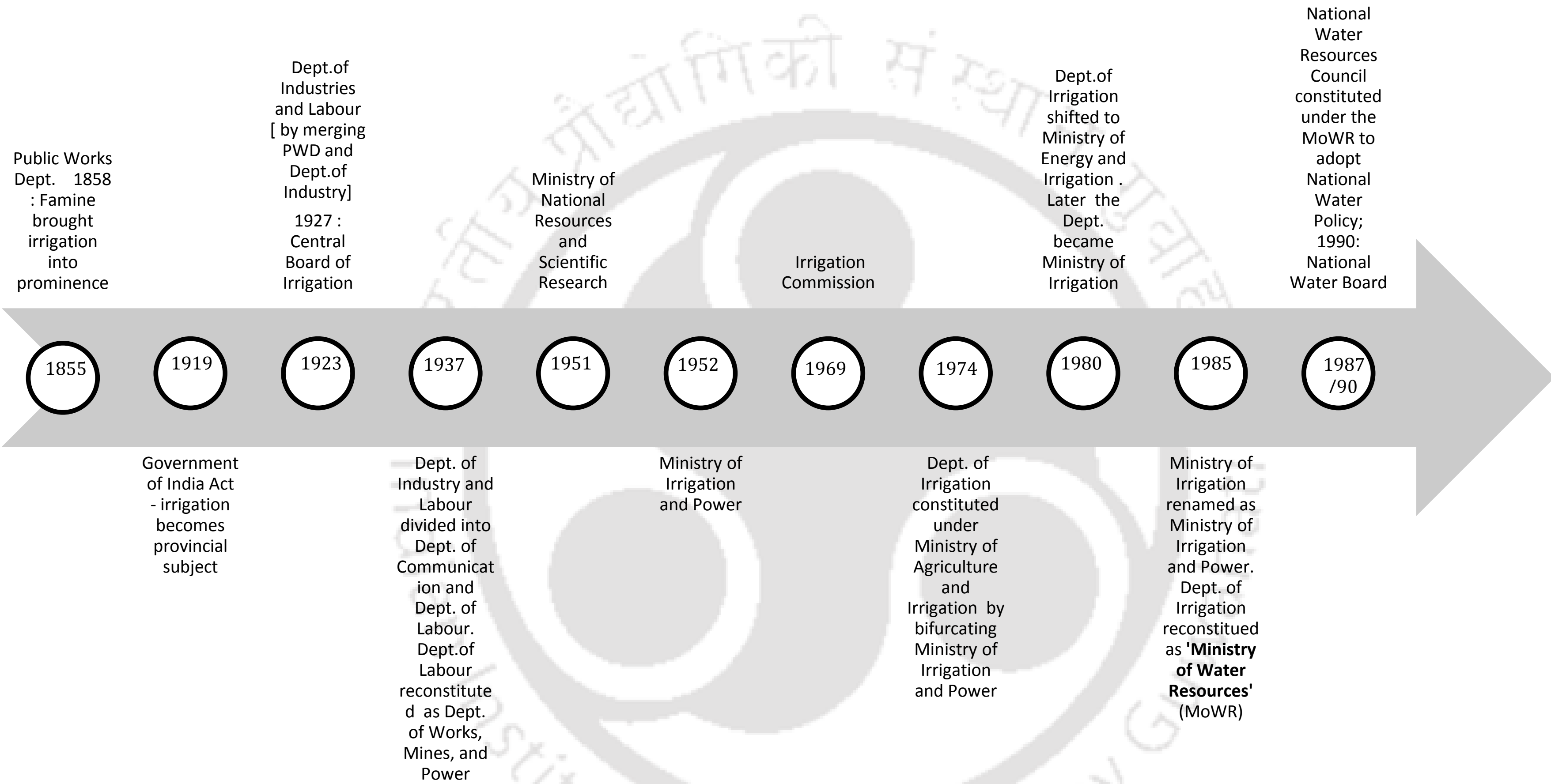

Figure 6.1: Depiction of how irrigation and power played a central role in realizing a need to constitute MoWR and adopt NWP
Source: Compiled from (Government of India 2015b)

Groundwater (GW) has become a major source of water to meet ***drinking*** and ***irrigation*** demands, the top two priorities. It meets about 90% of drinking water and 60% of irrigation demand(Government of Andhra Pradesh 2008, Government of Chhattisgarh 2012). Although NWP 2002 recognizes GW as a dominant source, it continues to focus on GW ‘development’ rather than ‘management’ (Aw-Hassan et al. 2014). GW development estimates do not consider geographical characteristics and seasonality which are crucial for sustainable use and management of GW (Bassi 2014). Due to which GW has been over-exploited[32] in highly water-scarce states like Punjab, Haryana, Rajasthan and Delhi (Figure 6.2). These states are highly water-scarce and net VW-exporters (Table 6.1). Among these only Rajasthan has implemented SWP. Punjab, the highest water losing state during 1996-2014, formulated a Draft SWP in 2008 which is yet to be accepted. The Draft SWP reflects an absence of a science-policy interface to arrest unchecked over-exploitation(Government of Punjab 2008). Further, even though SWPs voice concerns of GW over-exploitation, they lack discussion on state-specific strategies to curb it. Therefore, sustainable use and management of GW need to be flagged through science-policy interface.

[32] GW over-exploitation: abstraction rate exceeds replenishment rate

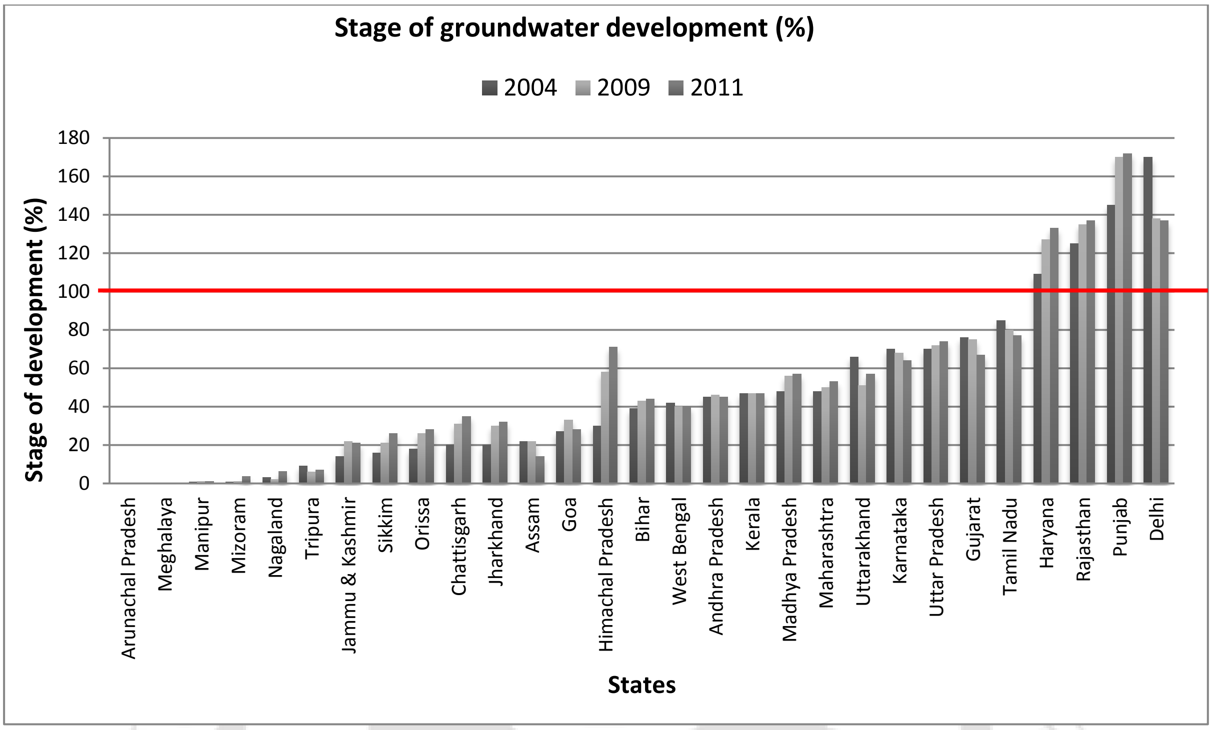

Figure 6.2: Stage of groundwater development (%)
Data sources: (Government of India 2006a, 2011a, 2014d)

Ecology figures as the fourth priority in the NWP even though water for ecology and environment is essential for ecosystem structure and functioning and the economy is a subset of the environment (Daly 2003). Orissa and Jharkhand SWP, have prioritized ecology over irrigation, i.e., ecology is the second water allocation priority. It is interesting to note here that based on the water scarcity and VW-flows analysis, both the states are moderately water-scarce and net VW-importers (Table 6.1).

Himachal Pradesh, which is a moderate to highly water- scarce state, and a net VW-importer, has grouped ecology with afforestation, biodiversity and tourism (Table 6.1). There is a concern that ecological issues would be overshadowed by the short-term benefits from tourism (Cullet 2009). Further, some of the SWPs have recognized EWR (approach III[33] to assess water scarcity), e.g., Himachal Pradesh considers that 'not less than 15% of available

33 Approach III discussed in section 4.1.3

discharge at any given time should be allocated for environmental needs'(Government of Himachal Pradesh 2005). However, the SWP does not refer to any specific method through which EWR of the rivers flowing through the state is established. In fact, EWR of Indus, a major river of Himachal Pradesh, has not been determined(Smakhtin and Anputhas 2006). This raises a concern on the strength of association among the scientific community and policymakers. With the importance of preserving e-flows in rivers being recognized by the latest NWP (2012), there is an opportunity to strengthen the science-policy interface for sustainable water use to mitigate water scarcity. This is crucial for the highly water-scarce states which are in the process of revising their SWPs, like Tamil Nadu. Tamil Nadu was one of the first states to formulate an SWP, i.e.1994, in accordance with the NWP (1987), in which water requirements of ecology and environment were not recognized as a water allocation priority.

The bifurcation of ***agro and non-agriculture industries*** is crucial primarily because of significant variation in water-intensities of the agro and non-agricultural based industries. Some SWPs differ from NWP on prioritization of these industries. While Karnataka prioritizes agro over non-agriculture industries, Maharashtra prioritizes agro-industries over irrigation and hydropower. This is because Maharashtra's economy specializes in agro-industries, and value-addition by industrial water use is higher than irrigation. This prioritization is an outcome of the formulation of Maharashtra SWP in consultation with The World Bank which reflects sub-national, national and international experiences in WRM (Cullet 2009). It is crucial to emphasize here that, both Karnataka and Maharashtra are net VW-importers (Table 6.1).

6.2.3. Water Use Efficiency

The third key indicator of science-policy interface in water policies is water use efficiency (WUE). Enhancing is a rationale of the VW-flows concept and a key policy area where VW research finds applicability (discussed in section 2.1 and sub-section 2.3.2). Poor WUE and productivity have been recognized as a persistent challenge since the first NWP (Government of India 1987, 2002a, 2012d).

To enhance the WUE in water-scarce areas, technological advancement, recognition of the economic value of water, and water markets are crucial strategies(Katyaini and Barua 2016). While SWPs have adopted the technologies proposed in NWP, they have not identified the technologies which are most suitable to mitigate water scarcity in the respective state. Secondly, SWPs do recognize the significance of the economic value of water for enhancing WUE through implementing water pricing and water rates, very few SWPs emphasize on scarcity value of water. Water pricing and water rates are widely implemented in states of India, however, they are only concerned with supply management (Perry 2003). For instance, water pricing is limited to the price of volume abstracted and supplied and is a strategy to manage water supply. Water rates are user based and are primarily imposed to fully recover operation and maintenance cost, and partially recover the capital cost. Therefore, water rates and water pricing approach falls short in introducing sustainability. Scarcity value is most ideal as it refers to the actual value foregone due to water scarcity(Ghosh and Bandhopadhyay 2009). Rajasthan, Uttar Pradesh and Kerala have recognized the importance of scarcity value. It is interesting to note that, among these states, Rajasthan is a highly water-scarce state with net VW-exports (Table 6.1). Uttar Pradesh SWP also proposes a need for reforms in legislation and institutional mechanisms to integrate scarcity value adequately.

As water scarcity has become economically binding, water markets have emerged. Voluntary and transferable water rights are crucial for functioning of water markets in water-scarce areas because they have a direct impact on water demand management (Saleth and Dinar 2004, Saleth 2011, Hillman, Douglas, and Terkla 2012). SWPs of Uttar Pradesh, Karnataka, Orissa, Jharkhand, Kerala and Maharashtra have integrated water rights. Some SWPs even suggest research avenues for ascertaining water rights, like Karnataka which emphasizes the need for integrated and coordinated applied research on basin water availability to formulate water rights. SWPs propose different mechanisms for determining and implementing water rights. For instance, Orissa proposes adoption of water rate norms to determine water rights, Kerala proposes micro watershed as the unit of implementing it. Maharashtra was the first state to functionalize trading of water entitlements (seasonal and annual) through Water Users' Associations (WUAs), with policy and legislative support. This reflects a step towards strengthening sustainable water use.

It can be inferred that the science-policy interface is at a nascent stage in SWPs of India for enhancing WUE. Pro-active states have initiated strengthening their water policies through the emphasis on scarcity value, and water rights for effective demand management. Interestingly all of these states are net VW-importers, hence are saving water (Table 6.1).

6.2.4.WATER SAVINGS

The fourth key indicator of science-policy interface in water policy is water savings. It is crucial to support policy decisions based on **hydrologic-economic-institutions** representations where water is considered as an important factor of production(Garrido et al. 2010, Aldaya, Matinez-Santos, and Llamas 2010). Spain is the first water-scarce nation in the world to integrate VW conceptual framework in water management through the inclusion of water footprint in the implementation of River Basin Management Plans by Government of

Spain(Garrido et al. 2010). The latest NWP was the first water policy of India to recognize the need for assessing water savings, sustainability of production and consumption to mitigate water scarcity (Government of India, 2012).

As the rationale of VW concept is ‘distribution of water scarcity’, and enhancing ‘global water use efficiency’ through net water saving, NWP (2012), indicates internalization of most advanced approach to assess water scarcity, i.e., approach IV, and the VW-flows conceptual framework (discussed in sections 2.1 and 4.1.4) (Roth and Warner 2008, Aldaya, Matinez-Santos, and Llamas 2010, Allan 2011, Tillotson et al. 2014). Although NWP (2012) has recognized the need to assess water footprint and water savings, none of the SWPs have integrated the water savings concept yet. This is because SWPs have not been revised based on the guidelines of the NWP (2012).

Through this research on inter-state VW-flows assessment (results are presented in section 5.2), the utility of internalizing VW flows concept in SWP has been demonstrated to make water use sustainable and mitigate water scarcity. To exemplify, highly water-scarce states which are also net VW-exporters need to consider VW-flows assessment while formulating or revising their SWPs for minimizing losses of their scarce water resources. This is particularly necessary for formulating SWPs of Punjab, Haryana, and Delhi, and revising SWPs of Andhra Pradesh, and Rajasthan (Table 6.1).

Knowledge created on water savings through assessment of VW- flows would be useful for ‘water zoning’ for economic development. This is because VW is a measure of the freshwater embodied in goods produced. At present, SWPs propose water zoning for economic development on the basis of water availability. Some of the SWPs have identified specific criteria for water zoning where VW-flows research can aid in strategizing water zoning. For instance, groundwater (Rajasthan), lifestyles and location (Karnataka), agro-climatic conditions (Jharkhand), and water-induced hazards[34], like droughts and floods (Tamil Nadu, Andhra Pradesh, Maharashtra, Madhya Pradesh, Jharkhand, Himachal Pradesh). The potential of VW-flows concept in strategizing water zoning emerges from its application for economic diversification, and conflict mitigation (as discussed in section 2.3.22.3)

6.2.5.STAKEHOLDERS' PARTICIPATION AND WATER LITERACY

Stakeholders' participation in policy making is crucial because it enables integration of local and scientific knowledge to understand socio-ecological systems(Johnson et al. 2004). As water scarcity is a multifaceted issue, stakeholders' participation is crucial for its mitigation. A greater autonomy in decision-making, and delegation of powers to user groups with institutional support results in intended benefits (Bassi and Kumar 2011). It builds cooperation, trust among stakeholders, a sense of ownership over decisions, equity, as well as learning, which is also known as water literacy (Dube and Swatuk 2002, Lawrence 2006, Reed 2008, Government of Rajasthan 2010). Water literacy enhances decentralization and user participation in policy making and implementation (Government of Karnataka 2002, Government of Kerala 2008). Therefore, it is important to know which stakeholders' engagement is encouraged in policy making and implementation, and to what extent.

In SWPs, the reference to stakeholders' participation is largely restricted to farmers, through Water Users' Associations (WUAs) and Participatory Irrigation Management (PIM) as irrigation is a water allocation priority (discussed in section 6.2.2). It is interesting to note here that SWPs of water savings states such as Tamil Nadu, Uttar Pradesh, Karnataka, Maharashtra, Orissa, Jharkhand and Kerala and water losing states like Andhra Pradesh, Rajasthan, and Chhattisgarh have identified stakeholder groups in addition to government and farmers whose participation is crucial (Table 6.1). These are Panchayati Raj Institutions

[34] Disaster management is also a 'state responsibility' in India. (Government of India 2009b)

(PRIs), water users groups (WUGs), legislators, civil society organizations, and non-governmental organizations (NGOs). Further, Orissa's SWP emphasizes the integration of the tribal population which forms a large part of the state's population. Maharashtra and Himachal Pradesh also seek to empower women through their participation in Water WRM. Although stakeholders' participation is considered important in policy making and implementation, policy formulation is largely considered a responsibility of the apex body. This is a typical view on stakeholders' participation and leads to the ineffectiveness of policy as there is a difference in their needs and provisions which are created (Estrella and Gaventa 2000, Reed 2008). Communities' participation is encouraged primarily in WRM in Maharashtra, Himachal Pradesh, Orissa, Jharkhand and Kerala SWPs. Their participation in resolving water conflicts has been provided with legislative support, for example in Himachal Pradesh, Orissa and Rajasthan SWPs. It is referred to as *water adalat* (Water Court) in Himachal Pradesh and *Pani Panchayat* in Orissa. They can also be called rudimentary water rights systems (Saleth 2011).

Multi-stakeholders' participation does not always happen in an equitable manner because there are power relations among the stakeholders (Dovers 2001, Kothari 2001). This is the main reason for private sector's participation in water policies being viewed with skepticism. Despite these concerns, some SWPs, like Himachal Pradesh and Jharkhand, consider the public-private partnership in water use and management. This because a public-private partnership is believed to improves service efficiency and accountability to users. In fact, Himachal Pradesh SWP has grouped participation of communities and the private sector in the same section. Cullet (2009) has raised the concern of marginalization of financially weaker users, and social inequity in grouping participation of communities and private sector. It can be inferred that there is a large scope for engaging stakeholders' in policy making as well as implementation to strengthen the science-policy interface. The learning experiences of pro-active states in engaging stakeholders, like Maharashtra, Karnataka, Orissa, Kerala and Himachal Pradesh needs to be considered. Particularly in highly water-scarce states which are net VW-exporters, such as Punjab, Haryana, Delhi, Rajasthan and Andhra Pradesh.

Secondly, water literacy of multi-stakeholders needs to be based on the integration of both natural and social sciences aspects to ensure that reliable information enters the policies. Excluding any of these disciplines would leave a gap in balanced understanding (Allison and Hobbs 2006, Hawke 2012). Water literacy needs to be ***inquiry-based***, and aimed at ***problem-solving*** at the science-policy interface ***to develop creative and critical thinking*** (Hawke 2012, Sammel and Mcmartin 2014). Maharashtra, Karnataka and Kerala, which are water savings states, are at the forefront of recognizing water literacy. They recommend its inclusion in the school curriculum; however, they restrict it to facts and figures of state water sector, means and methodology for sustainable water use, and conservation. Therefore, the current water literacy framework leaves a knowledge gap in gaining a holistic perspective.

The positive steps prescribed in SWP of Maharashtra to enhance the effectiveness of water literacy is to improve coordination among education and research institutes for the dissemination of knowledge, information and State-of-the-Art Technology. Kerala SWP considers water literacy of the user, i.e., on water rights, in addition to, water literacy of youth through formal education. Enhancing water literacy of farmers is crucial because there is a low translation of scientific knowledge into in governance and management of water resources. This is evident from the findings of the 68th round of National Sample Survey (NSS), which indicate that largely, i.e., 70% of farmers rely on progressive farmers, commercial agents and radio/TV/ the internet for water literacy and agriculture knowledge. Only 15% of the farmers sourced technical advice from extension workers (Krishi Vigyan Kendra's and agricultural universities put together) (Editorials 2016).

6.2.6. SUMMING UP

An examination of the strength of the science-policy interface in water policies of India reveals that it is at a nascent stage because of the knowledge-governance gap. The gap results from a lack of adequate communication between the knowledge creators and governance system. This is evident in the fact that only a few water policies documents recognize the latest scientific evidence and research on water scarcity. For instance, water scarcity is still referred to in terms of the first approach only, i.e., based on human water requirements. There is a lack of integration of the latest scientific (natural and social) knowledge in policy discourse to address state-specific water scarcity concerns in India. This is crucial for enabling well-informed policy making and effective implementation. To exemplify, sustainability is primarily discussed in terms of the agriculture sector because of its relevance to food and livelihood security. While sustainability needs to refer in terms of social, economic and environmental sustainability of the resource, sustainability in water policies is predominantly referred to as economic sustainability. Even though environmental sustainability has been recognized in NWP (2002 and 2012) and SWPs, it is open to interpretation, which is a concern. There is also a lag in the integration of scientific knowledge on aspects like water rights, water footprints, and water savings to enhance environmental sustainability. Among the three dimensions of sustainability, social sustainability is least cited in water policies. The concerns associated with equity and mechanisms to enable multi-stakeholders' participation in both formulation and implementation of water policies are not adequately addressed. Environmental sustainability can be enhanced by recognizing climate-driven water scarcity in SWPs and water allocation for environment and ecology based on scientific evidence with a view of long-term gains. There is a need to integrate current research findings on water use efficiency and water savings for both environmental and economic sustainability. A paradigm shift towards social sustainability is reflected in increased stakeholders' participation at different stages of policy implementation in national and state water policies. Institutional mechanisms need to evolve further through policy dialogues with, and coordination among, multi-stakeholders. This is because in the present context, policy formulation and its implementation, more often than not, are undertaken by different groups of people, thus leading to a situation of dichotomy which affects the overall outcome, i.e., sustainable resource management.

Another challenge which acts as a barrier in translating scientific knowledge into action, and needs to be countered to strengthen the interface is the slow pace at which exchange of information happens and relevant scientific research finding are internalized in water policies. This is attributed to lack of communication, and trust among scientists, policy makers and implementing agencies. It is crucial to keep the pace of policy making with changes in the water scarcity scenario, in order to achieve water security. Therefore, a space for interactions is needed to enhance knowledge sharing for policy making and building strong and continued association to map science-policy interface through the entire sequence of components of policy formulation and implementation.

The persisting knowledge-governance gap can be addressed through up-scaling and replicating capacity building on social, infrastructural and institutional aspects through water literacy in formal education, among users as well as multi-stakeholders at sub-national scale. This would facilitate functionalizing the property rights over water resources which are context specific. Only a few SWPs have integrated water literacy, there is a need for other SWPs to integrate it based on collective experience of states which have implemented water literacy. This would be important to encourage co-creation of sustainable water management strategies. Many highly water-scarce states have not yet implemented state-specific water policies. In these states, interactions and knowledge creation at the science-policy interface offer a great opportunity to devise new water policies. Stakeholders' participation in policy formulation brings in local and scientific knowledge which is important to understand the multidimensional nature of water resources. It also provides an avenue to build cooperation, trust, and ownership of the decision, and water literacy.

Based on the discussion here, it can be inferred that there is a need to rethink water policy to integrate the science-policy interface. However, it remains a big challenge for mitigation of water scarcity. Strengthening the science-policy interface in the water sector of India would enable formulation of evidence-based water policies as well as effective implementation. Further, only a few states have implemented SWP. There is a need for a strong indication to states without a water policy, which are facing high water scarcity or are approaching it, to formulate and implement SWP. They need to consider the opportunities at the science-policy interface. Lastly, here the emphasis was on the process of policy formulation and implementation to understand the science-policy interface. As policy is only a statement of intent, how far it is actually implemented depends mainly on regional leadership, the perception of the severity of resource scarcity and financial condition of the regional government.

The next chapter is on the key outcomes and recommendations of the research.

Chapter 7 KEY OUTCOMES AND RECOMMENDATIONS

This chapter comprises of three sections. The first section revisits the research hypothesis stated in sub-section 2.2.1.1.1. The second section presents the key conclusion and policy recommendations and the last section highlights the scope for future research.

7.1. REVISITING THE RESEARCH HYPOTHESIS

The research hypothesis was formulated considering ***water endowments*** as a source of comparative advantage.

Null hypothesis [H_0^1]: A relatively water-rich state, i.e. low water scarcity, ***exports*** relatively high water-intensive goods (with a high WF) and ***imports*** relatively low water-intensive goods (with a low WF).***This indicates that relatively water-rich state is a net VW-exporter.***

Alternate hypothesis [H_1^1]: A state with relatively high water scarcity, ***exports*** relatively high water-intensive goods (with a high WF) and ***imports*** relatively low water-intensive goods (with a low WF). ***The alternate hypothesis reflects that relatively highly water-scarce state is a net VW-exporter.***

From the VW-flows assessment of the two periods, i.e., 1996-2005 and 2005-2014 discussed in Chapter Chapter 5, it can be inferred that even though there are net WS at the national level, there are significant water losses through net VW-exports from the highly water-scarce states like Punjab, Haryana, Delhi, Andhra Pradesh, and Rajasthan. Further, there are net VW-imports in relatively water-rich states, like Goa, Kerala, states of North-East zone. These findings are in agreement with the alternate hypothesis stated above, therefore, based on the inter-state VW-flows assessment in India **alternate hypothesis is accepted**.

Net VW-exports from highly water-scarce states are considered as unsustainable VW-flows, because through these flows water scarcity is not being distributed, rather it is being concentrated in highly water-scarce zones. Secondly, these unsustainable VW-flows also indicate the creation of pollution haven in the highly water-scarce states where production is taking place. Therefore, highly water-scarce states in India do not take full advantage through importing water-intensive food grains and oilseeds to distribute and mitigate water scarcity.

These findings are in agreement with the VW-flows assessments of other nations which are grappling with water scarcity, such as Spain, China, Australia, and MENA (Allan 1997, Wheida and Verhoeven 2007, Roth and Warner 2008, El-Fadel and Maroun n.d., Wichelns 2001, Velázquez 2006, Aldaya, Matinez-Santos, and Llamas 2010, Elena and Esther 2010, Cazcarro et al. 2011, Lenzen and Foran 2001, Guan and Hubacek 2007, Zhang, Yang, and Shi 2011).

It can be inferred from the assessment that the driver of VW-imports is the food requirements of a large population in the state with the largest VW-imports, i.e., Maharashtra in the post-reforms period, and Tamil Nadu in the period of recovery up to 2014. The driver of VW-exports is relatively larger arable land in the state with the largest VW-exports, i.e., Punjab in both the post-reforms period and period of recovery up to 2014.

From the discussions in Chapter Chapter 4, Chapter 5, and Chapter 6, it can also be inferred that state-specific water policies also create the comparative advantage for the highly, and moderate to highly water-scarce state. To illustrate, relatively larger number of states which have formulated and implemented SWPs are VW-importers, i.e., have water savings through inter-state VW-flows. This includes Maharashtra and Tamil Nadu, which are highest water savings states during the two periods 1996-2005, and 2005 and 2014. The absence of an SWP for Punjab has created a comparative disadvantage for the state as it is experienced highest water losses during both the time periods considered and in fact the water losses increased tremendously during the 2005-2014. This is in agreement with Suranovic (2007) and (Verma et al. 2009) as they suggested that existence of ***government policies*** governing the use and management of natural resources is a source of comparative advantage or disadvantage, in addition to that of natural resources' endowments.

7.2. CONCLUSION AND POLICY RECOMMENDATIONS

The discussion on conclusion and key policy recommendations is organized according to the two expected outcomes of this research stated in section 1.4.

Expected Outcome I: Mainstream water as a factor of production in policy decisions for sustainable management of water resource

At present, decisions on agriculture are primarily based on land productivity, i.e., yield improvements (agriculture output in kg/ per unit of area). Although the emphasis on land productivity through green revolution, has led to enhanced food production, it has also caused severe depletion of water resources. Despite the evidence provided through scientific research, scant attention is being paid to the sustainability of water resources. The concerns of water resources have not been adequately internalized in the ongoing green revolution II for enhancing production of oilseeds and pulses in Eastern region. The assessment of inter-state VW-flows embedded in food grains and oilseeds for the period of 1996-2014 (findings of which are discussed in Chapter Chapter 5), demonstrates the significance of mainstreaming water as a factor of production in policy discourse on sustainable water use and management to mitigate water scarcity.

The assessment integrated water resources as both the source and the sink to the economy. The findings suggest that there is a need for continued policy emphasis on 'water as a source' in rainfed agriculture[35]. This is because rainfed agriculture comprises a significantly large share of the agriculture in India and is crucial for water, food security as well as livelihood security. Another major concern where policy emphasis needs to be enhanced is sustainable GW use (section 6.2.2). This is crucial because GW is a major source of irrigated agriculture[36] and GW has been over-exploited in the highly water-scarce zones which are also major producers (Figure 4.8, Figure 5.2, Figure 5.6, Figure 5.11, Figure 5.15, Figure 6.2, Table 3.2 and Table 3.3). Further, there is a need for enhancing policy focus on water as a 'sink' of the economy in highly water-scarce states/zones which are producing food grains and oilseeds to meet the requirements of the importing states/zones. While meeting the requirements of the importing states/zones the producing state is adding water pollution[37] to its scarce water resources which creates pollution haven. Therefore, for sustainable use and management of water resources, it is essential to mainstream water as a factor of production in policy decisions.

Expected Outcome II: Emphasize the importance of science-policy interface to adequately address the issue of water scarcity

Through the critical review of NWPs and SWPs in the context of mitigation of water scarcity and inter-state VW-flows assessment (discussed in Chapter Chapter 5and Chapter 6), a need for rethinking water policies at a strong science-policy interface has emerged. At present, science-policy interface in water policies of India is at a nascent stage. There is a large scope to strengthen the science-policy interface to mitigate water scarcity. *Firstly*, through decentralized decision-making by formulating SWPs to address state-specific water scarcity concerns. It has been observed that the states have been able to save water because of their pro-active approach to governance and management of water resources through state-specific

[35] Rainfed agriculture: main component of rainfed agriculture is green WF
[36] Irrigated agriculture: main component of irrigated agriculture is blue WF
[37] Water pollution: captured through grey WF

water policy. *Secondly*, through the adoption of holistic approach for formulating water policies. A holistic approach is reflected in internalization of water resources as both a source and sink of the economy. *Thirdly*, through periodic water policy formulation and implementation at the state level is essential for integrating the scientific (both natural and social sciences) knowledge in policies. States have not revised their SWPs periodically, which is reflected in the lack of policy emphasis on important drivers of water scarcity, such as climate change, and on water productivity as the main criteria for decision making of BGREI on green revolution II. *Fourthly*, through integrating relevant experiences of other states in formulation and implementation of water policies. *Lastly*, through integrating genuine concerns of the state itself are crucial for strengthening science-policy interface in water policies.

7.3. LIMITATIONS OF THE STUDY AND SCOPE FOR FUTURE RESEARCH

This section discusses the limitations of the present research and identifies the avenues for future research. This research is a primer for building further knowledge to support the formulation of evidence-based policies which can be implemented to distribute and mitigate water scarcity through sustainable water use. The limitations of the study are in the context of data, research design and impact.

7.3.1. DATA

There are several parameters on which data gaps existed which limited the scope of this research. This section emphasizes on these data limitations which need be addressed to enhance the precision of VW-flows assessment for India in the future.

Firstly, the inclusion of **inter-state movements of goods by modes other than rail** would be important. Agriculture goods are largely transported by rail, river and road. The inter-state VW-flows assessment of food grains and oilseeds is based on the movement by rail only. This is because even though data on movement by road is significant; it is not yet collected by DGCIS (discussed in section 3.2.2). Although Ministry of Road Transport and Highways does collect data on goods transported by road, there is no official data on origin or destination, which is crucial for assessing the sustainability of inter-state VW-flows. Therefore, for enhancing the scope of the research, there is a need to collect data on the inter-state movement of agricultural goods by all modes of transportation. With the improvements in the road network, inter-state movement of agriculture goods by road increases. Therefore, the inclusion of inter-state movement by road in the VW-flows assessment would be a crucial addition to quantification of VW-flows.

Secondly, in this assessment, two major **categories of agriculture products**, food grains and oilseeds, were considered. The addition of cash crops like sugarcane, coffee, tea, and rubber, and other important agriculture products such as fruits and vegetables, and spices, would be crucial. This is because they are water-intensive crops, and assessment of inter-state VW-flows embedded in the movement of these crops would have important policy implications. In order to, integrate these agriculture products in the future assessment of VW-flows, collection of data on their inter-state movement by the concerned government department needs to be improved.

Thirdly, among the **economic sectors**, the focus of VW-flows assessment in this research is on agriculture. As the economy of India is diversifying with the emphasis being laid on manufacturing and services sectors. Future scope of research on VW-flows can be enhanced through integration of the manufacturing and services sector along with agriculture sector. However, there are data limitations as the water footprints of manufacturing and services sector have not been established at sub-national scale in India.

Fourthly, due to limited data on **differential quality and scarcity value of water**, these aspects were not considered. Internalizing these would be crucial for tackling 'scarcity of water resource' through technical efficiency.

7.3.2.RESEARCH DESIGN

This section dwells upon the limitations of the research design used for this study and proposes the future scope of research.

The research design used for the study is primarily to examine the inter-state VW-flows embodied in agriculture products. To integrate other sectors of the economy, other methodological approaches which inter-link the three economic sectors need to be considered, for instance, the environmentally-extended input-output analysis. This would require overcoming the data limitations of water footprints of manufacturing and services sector, and develop state-level input-output tables for the period of assessment.

7.3.3.IMPACT

This section encompasses the limitations of the impact of the current research, and research avenues for further research on science-policy interface to mitigate water scarcity in India.

Firstly, the policy discussion is largely in the context of water policy, future research on the integration of trade and agriculture policies in the discussion would be a crucial value addition to gain in-depth knowledge on policy directions on not only water security but also food and livelihood security.

Secondly, the impact of the research considers water endowments as a source of comparative advantage and the government policies to discuss the science-policy interface to mitigate water scarcity. The future scope of research is to examine other sources of comparative advantage, such as preferences induced by per capita income, demand, economies of scale, and network effect (discussed in section 2.2.1.1.1).

Lastly, the impact of the research can be expanded through the dissemination of the research findings with multiple stakeholders. This would generate awareness on sustainable water use and strategic water savings as well as add to strengthening the science-policy interface.

The limitations and scope of future research of data, research design and impact emphasized upon in this section indicate towards future scope of VW research in India, and other agriculture-based and emerging economies which grapple with water scarcity mitigation due to a weak science-policy interface.

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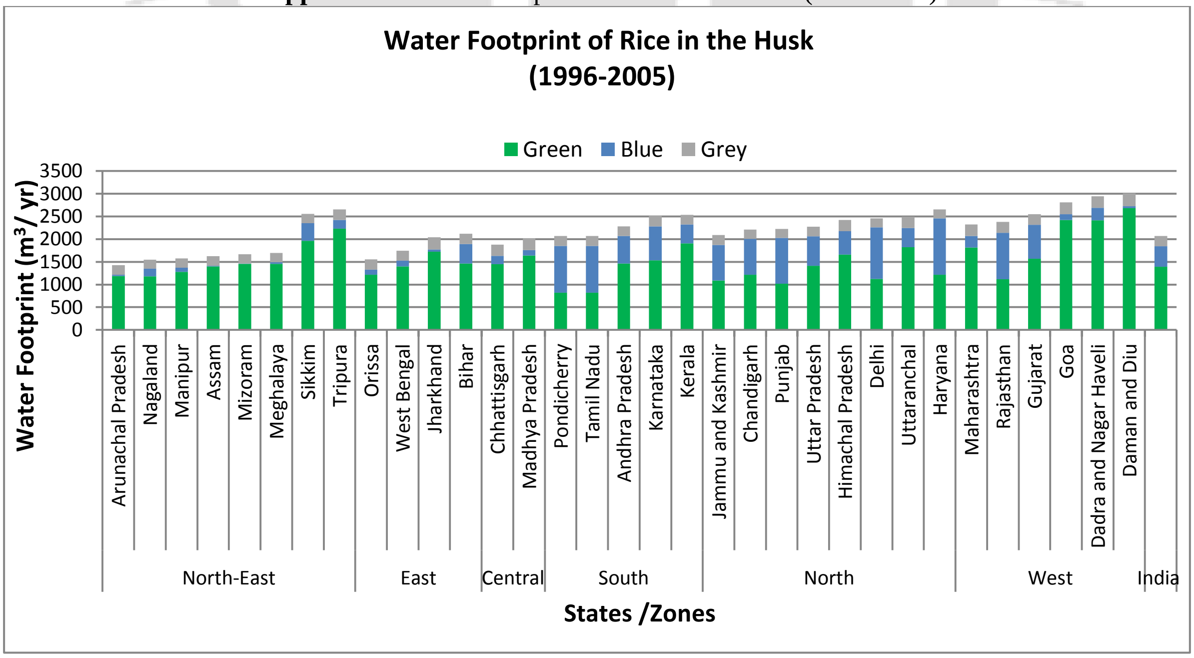
APPENDIX

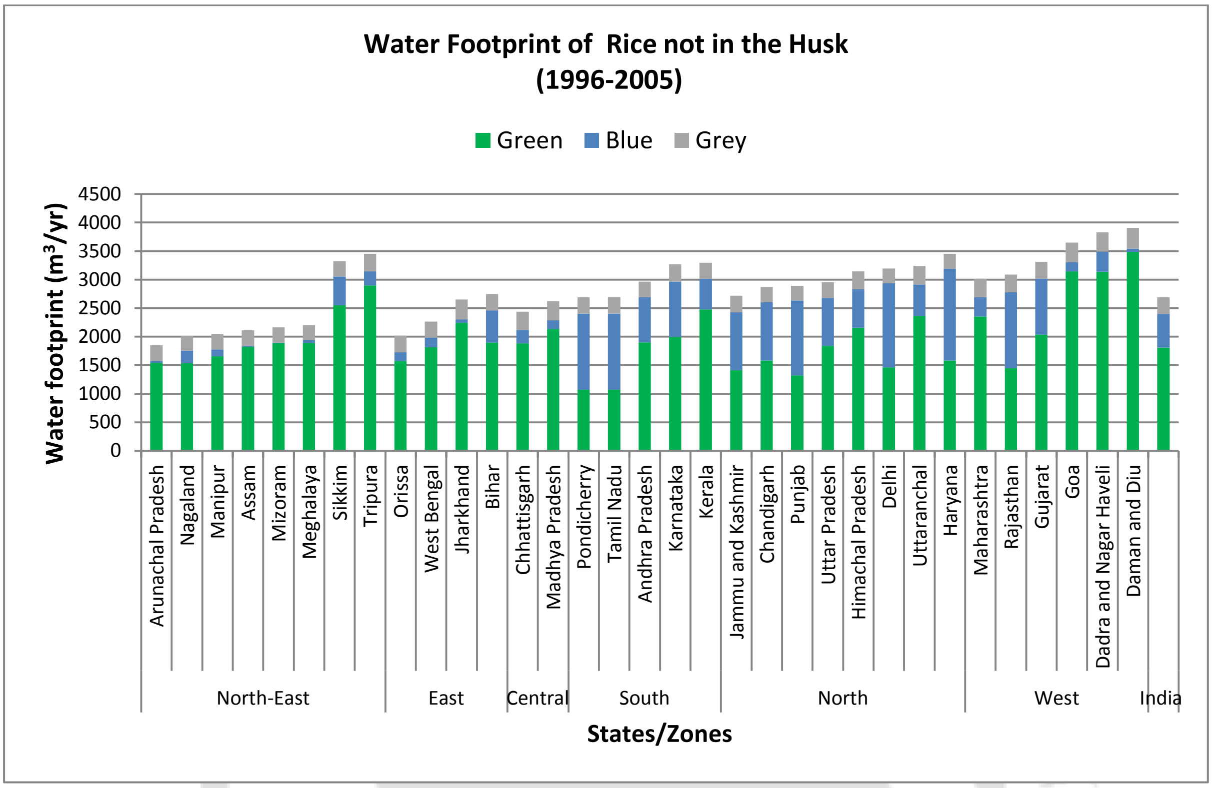
Appendix 1: Classification of States into Zones

Zone	North	North-East	East	Central	West	South
States/ UTs	Delhi	Arunachal Pradesh (AR)	Bihar	Chhattisgarh	Goa	Andhra Pradesh (AP)
	Haryana	Assam	Jharkhand	Madhya Pradesh (MP)	Gujarat	Karnataka
	Himachal Pradesh (HP)	Manipur	Orissa (Odisha)		Maharashtra	Kerala
	Jammu & Kashmir (J&K)	Meghalaya	West Bengal (WB)		Rajasthan	Tamil Nadu (TN)
	Punjab	Mizoram			Daman & Diu	Pondicherry (Puducherry/Pondicheri& Karaikal (P&K))
	Uttar Pradesh (UP)	Nagaland			Dadra and Nagar Haveli	
	Uttaranchal	Sikkim				
		Tripura				

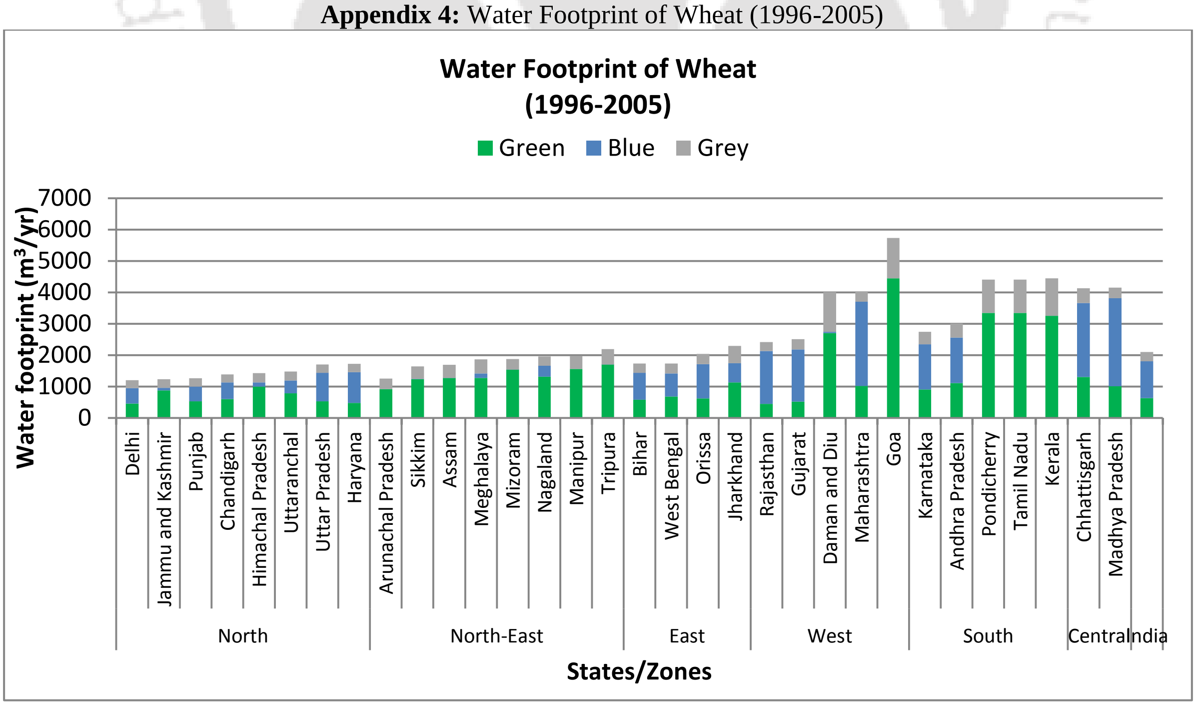
Appendix 2: Water Footprint of Rice in the Husk (1996-2005)



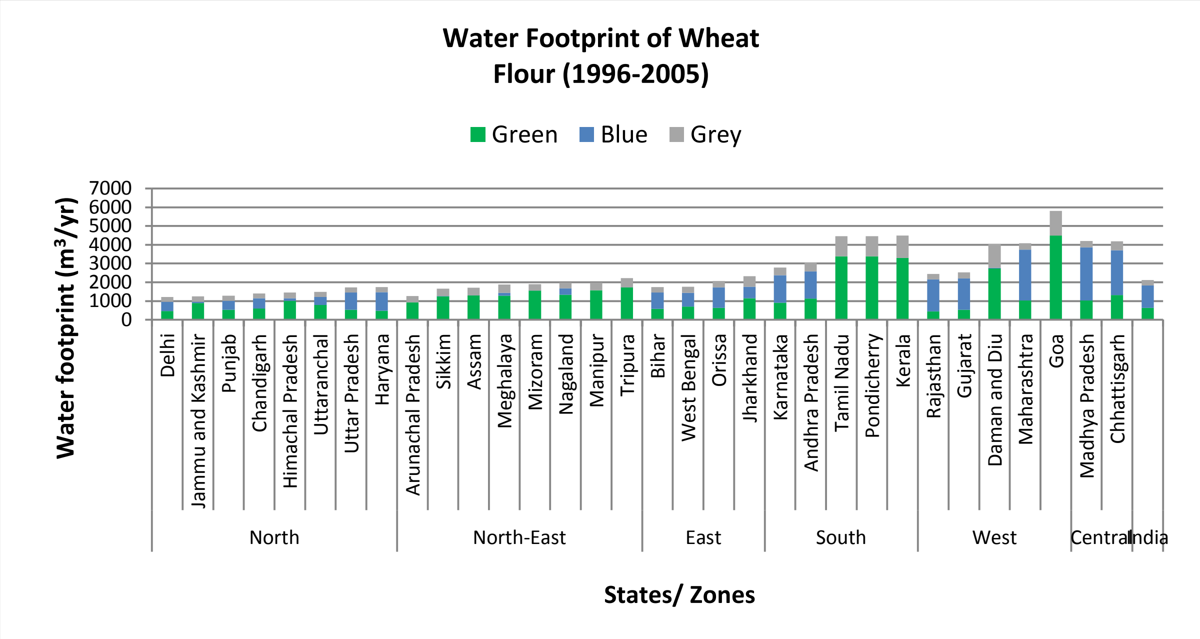
Appendix 3: Water Footprint of Rice Not in the Husk (1996-2005)



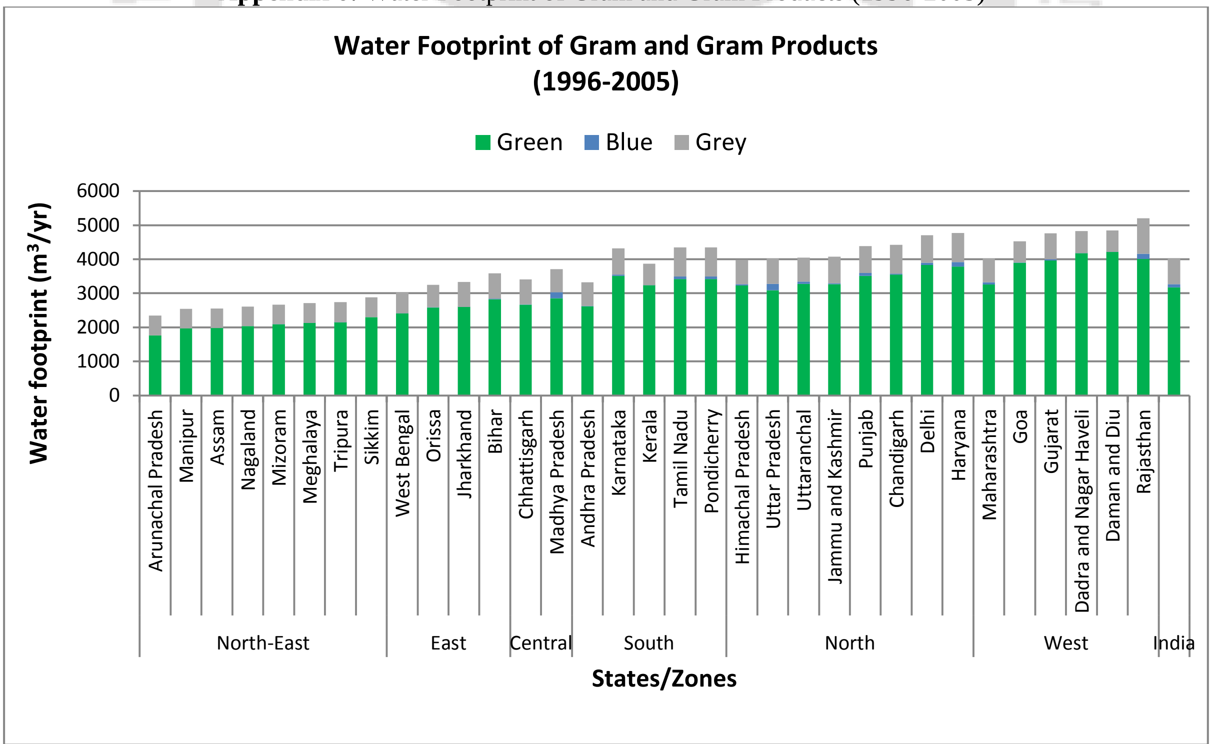
Appendix 4: Water Footprint of Wheat (1996-2005)



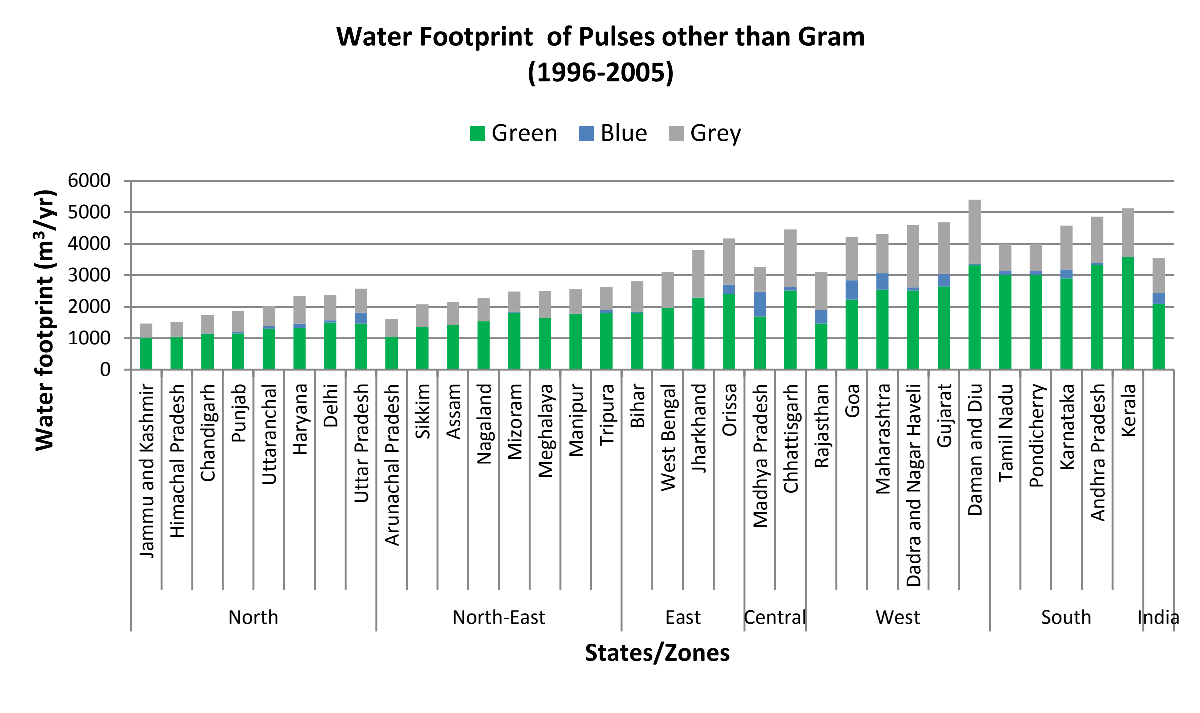
Appendix 5: Water Footprint of Wheat Flour (1996-2005)



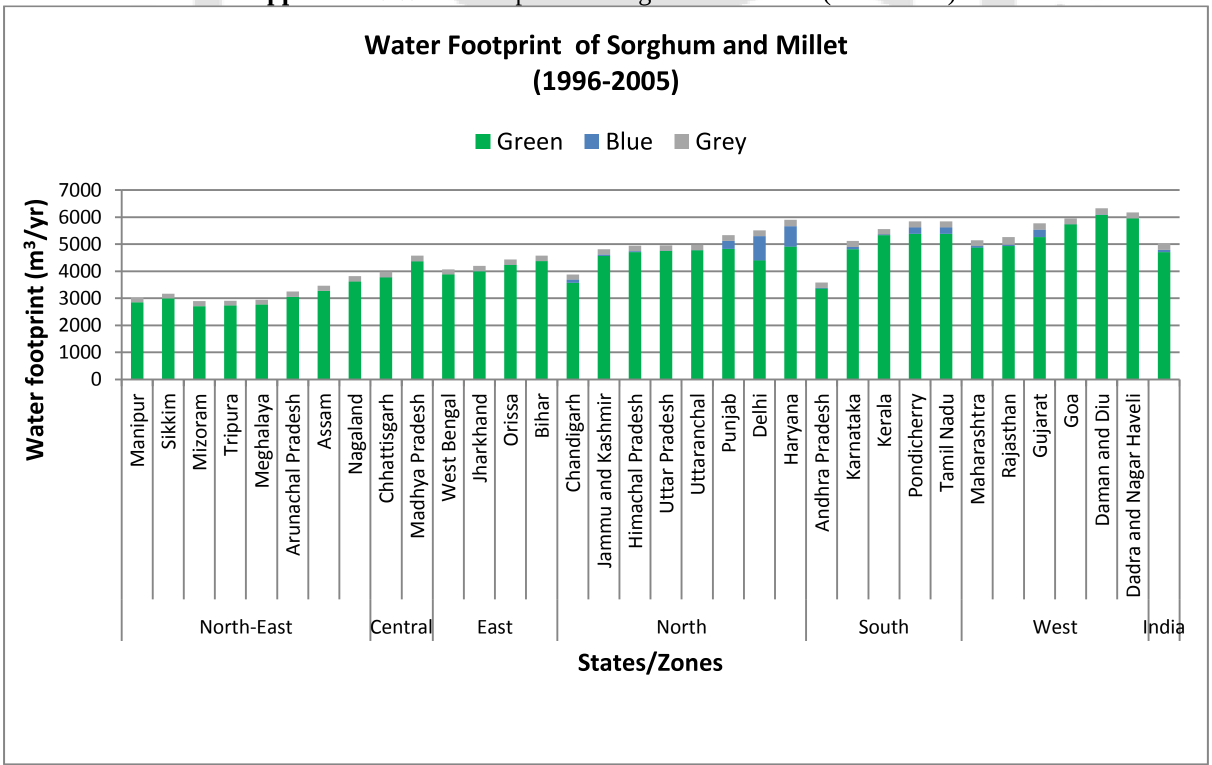
Appendix 6: Water Footprint of Gram and Gram Products (1996-2005)



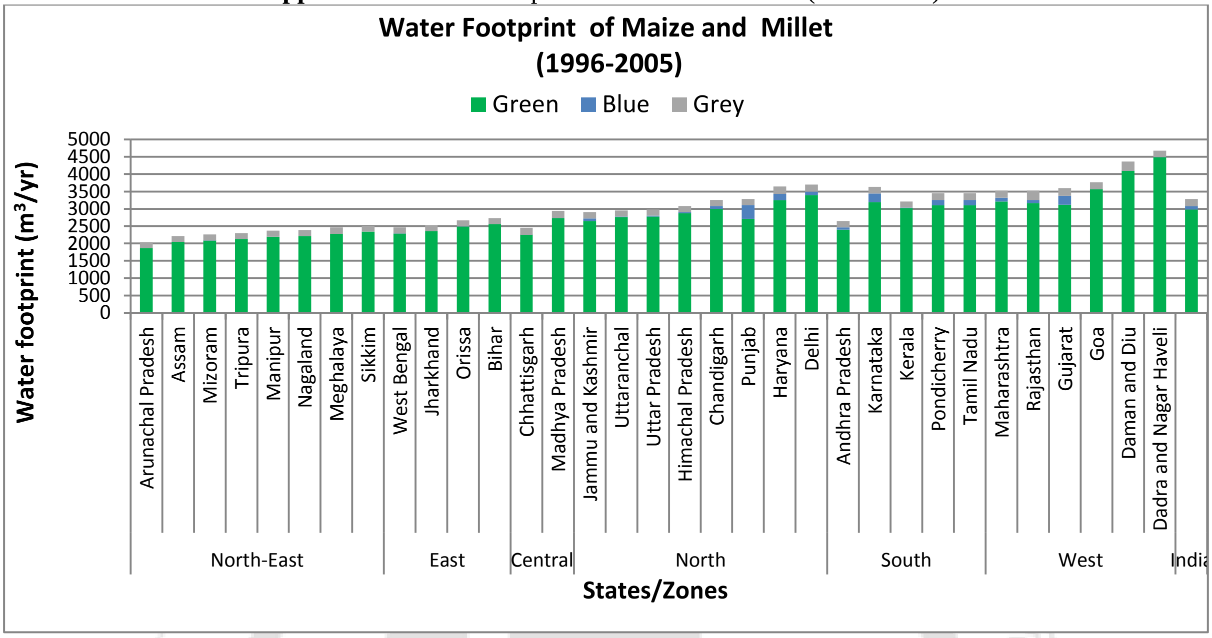
Appendix 7: Water Footprint of Pulses other than Gram (1996-2005)



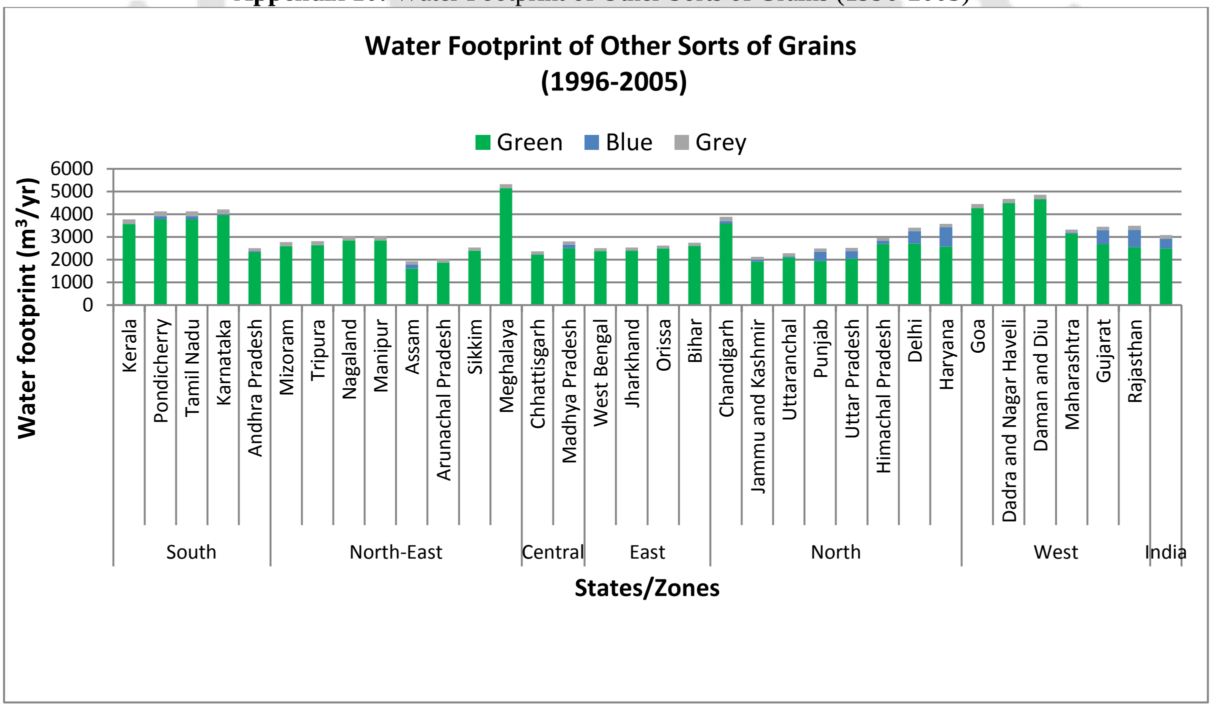
Appendix 8: Water Footprint of Sorghum and Millet (1996-2005)



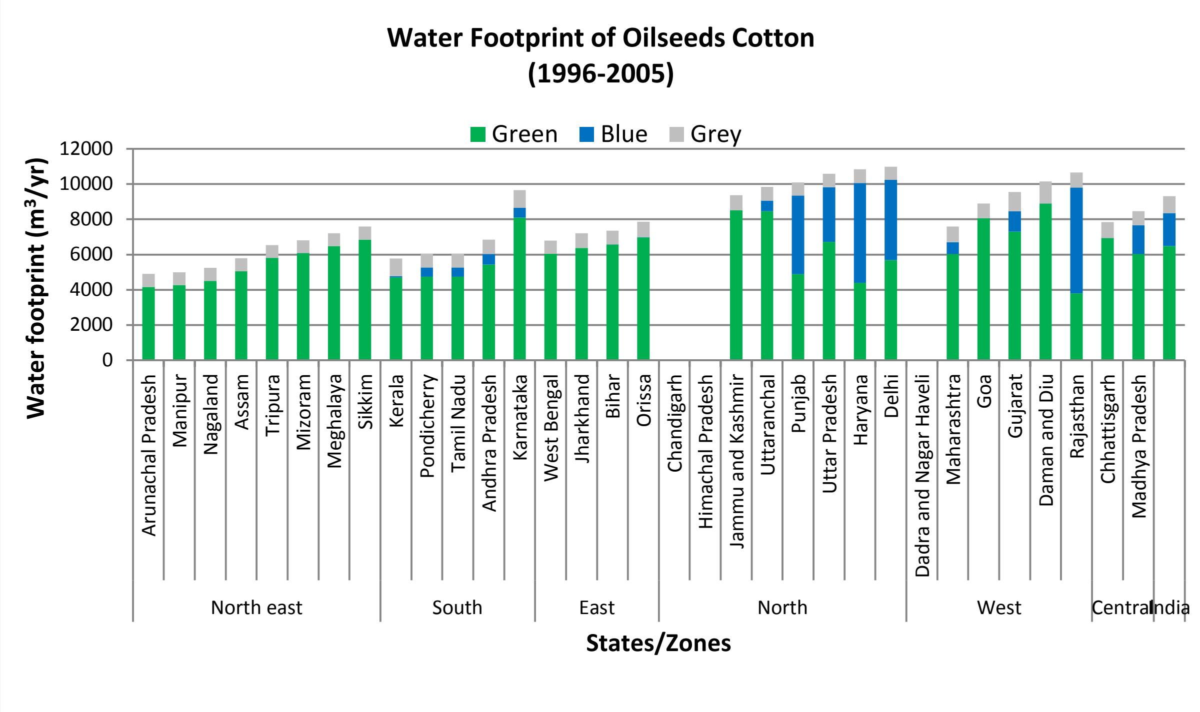
Appendix 9: Water Footprint of Maize and Millet (1996-2005)



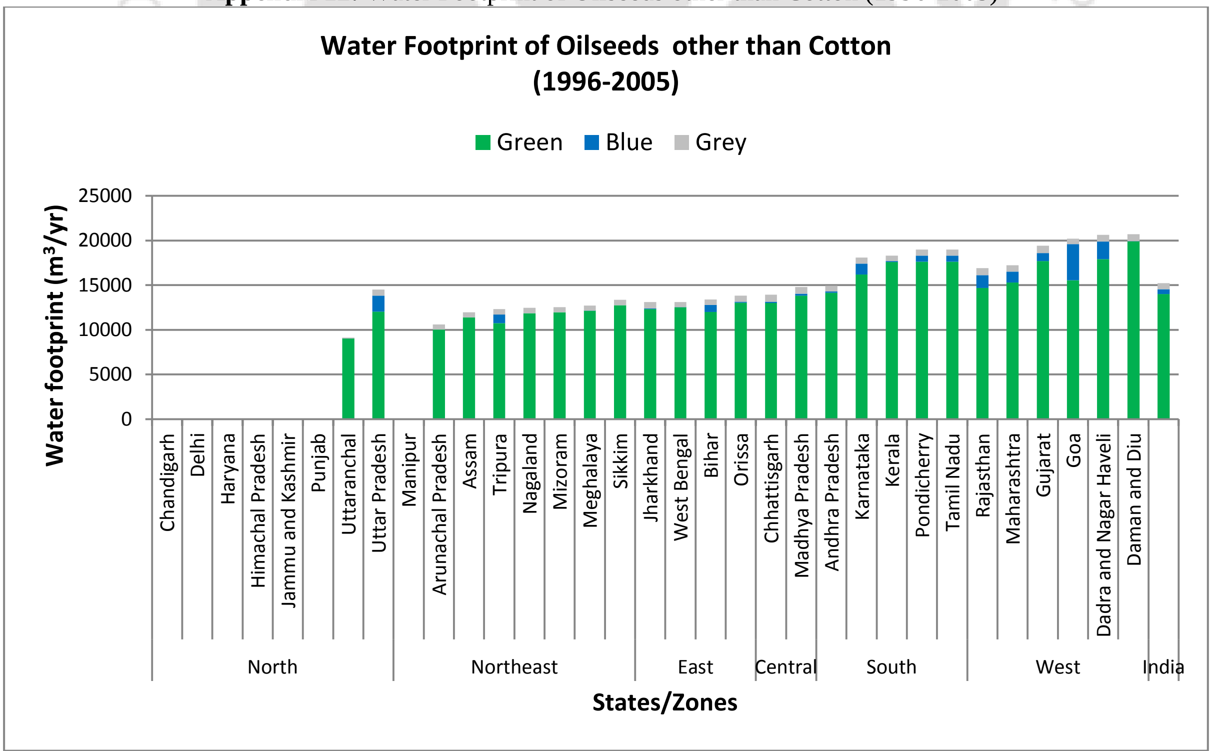
Appendix 10: Water Footprint of Other Sorts of Grains (1996-2005)



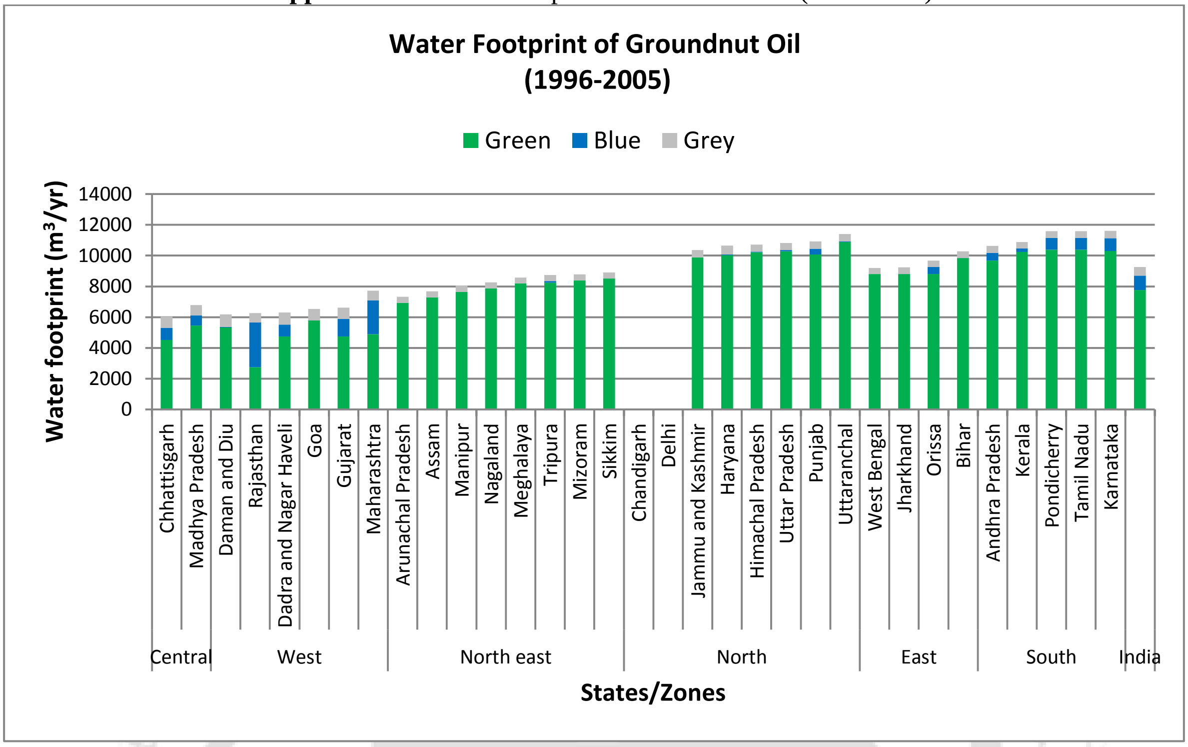
Appendix 11: Water Footprint of Oilseeds Cotton (1996-2005)



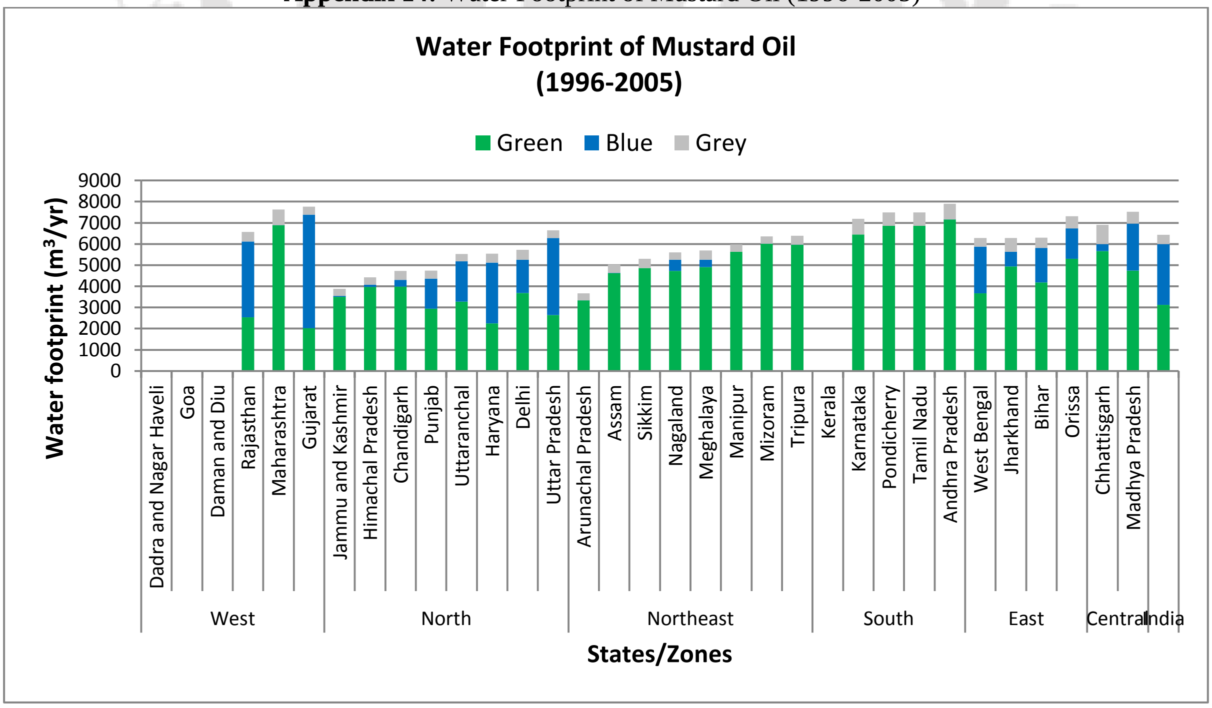
Appendix 12: Water Footprint of Oilseeds other than Cotton (1996-2005)



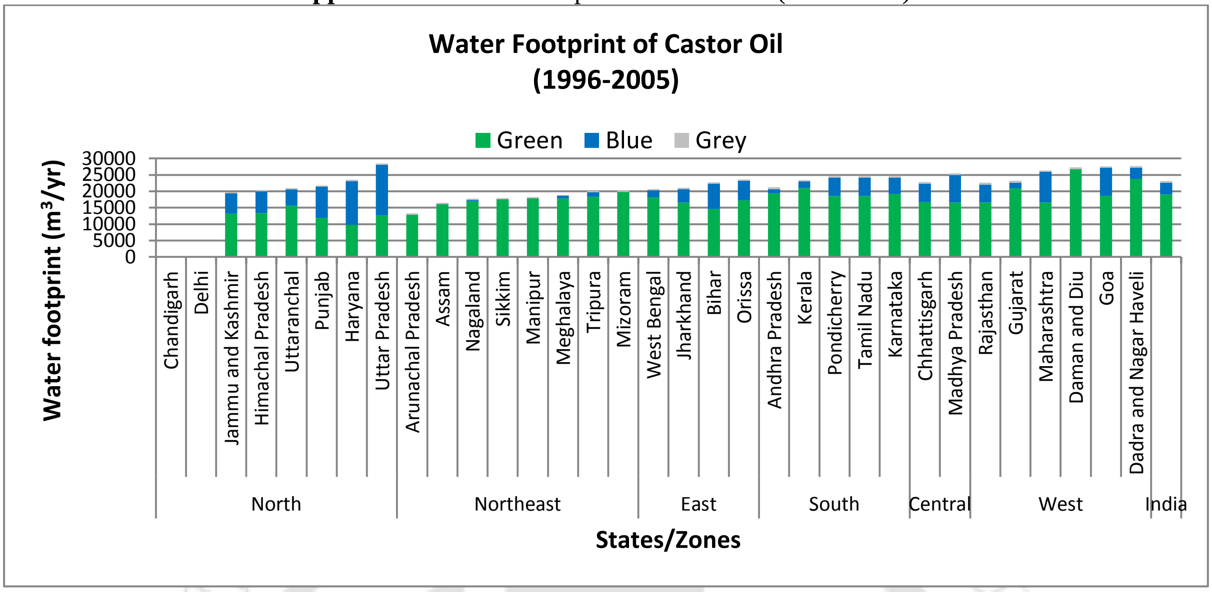
Appendix 13: Water Footprint of Groundnut Oil (1996-2005)



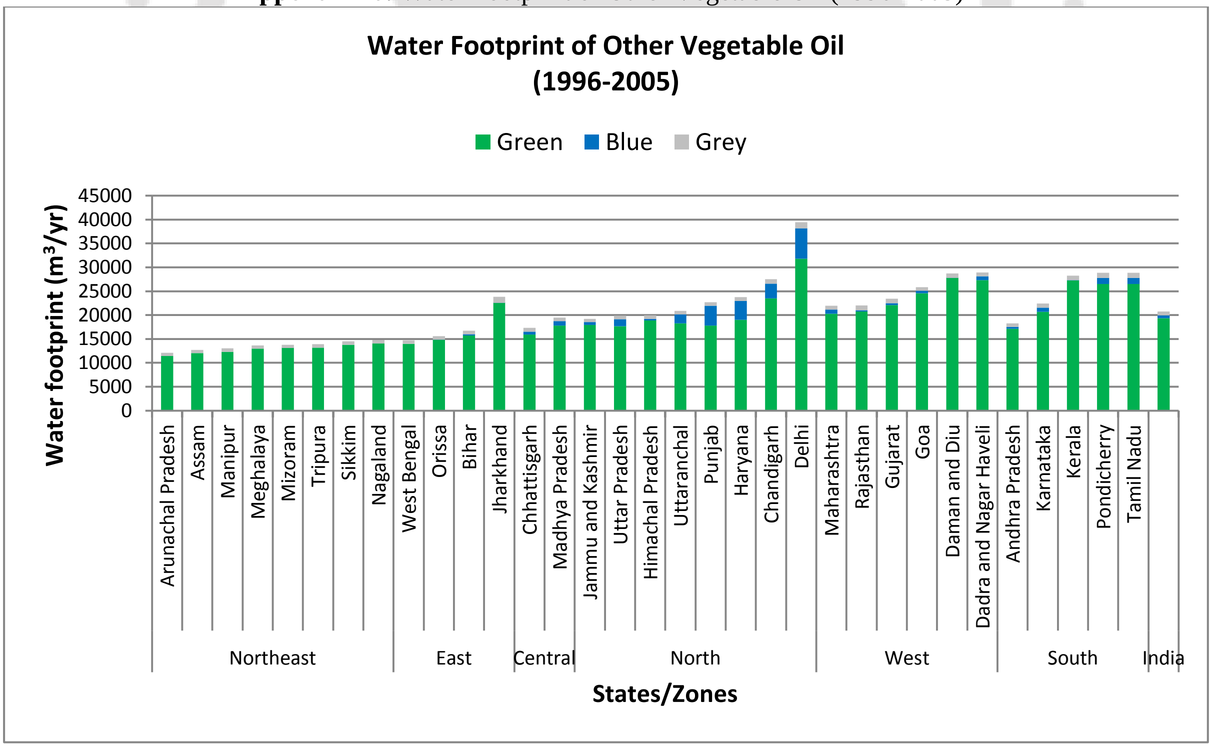
Appendix 14: Water Footprint of Mustard Oil (1996-2005)



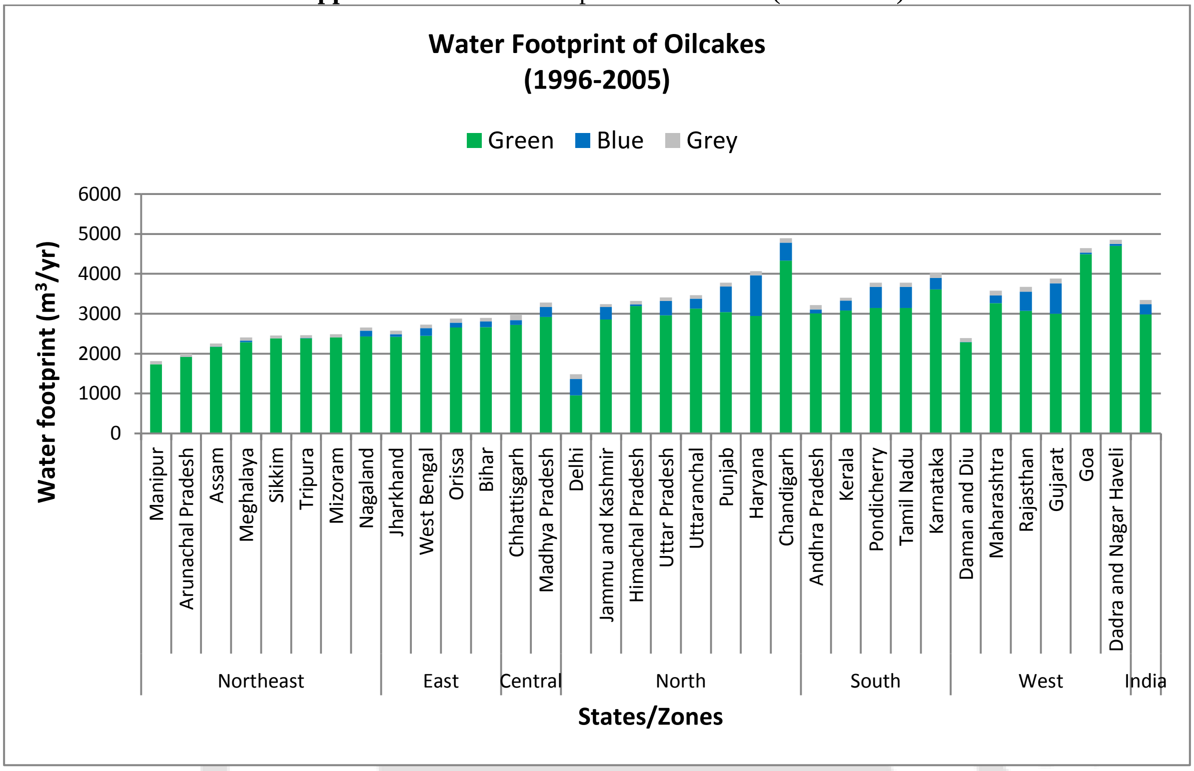
Appendix 15: Water Footprint of Castor Oil (1996-2005)



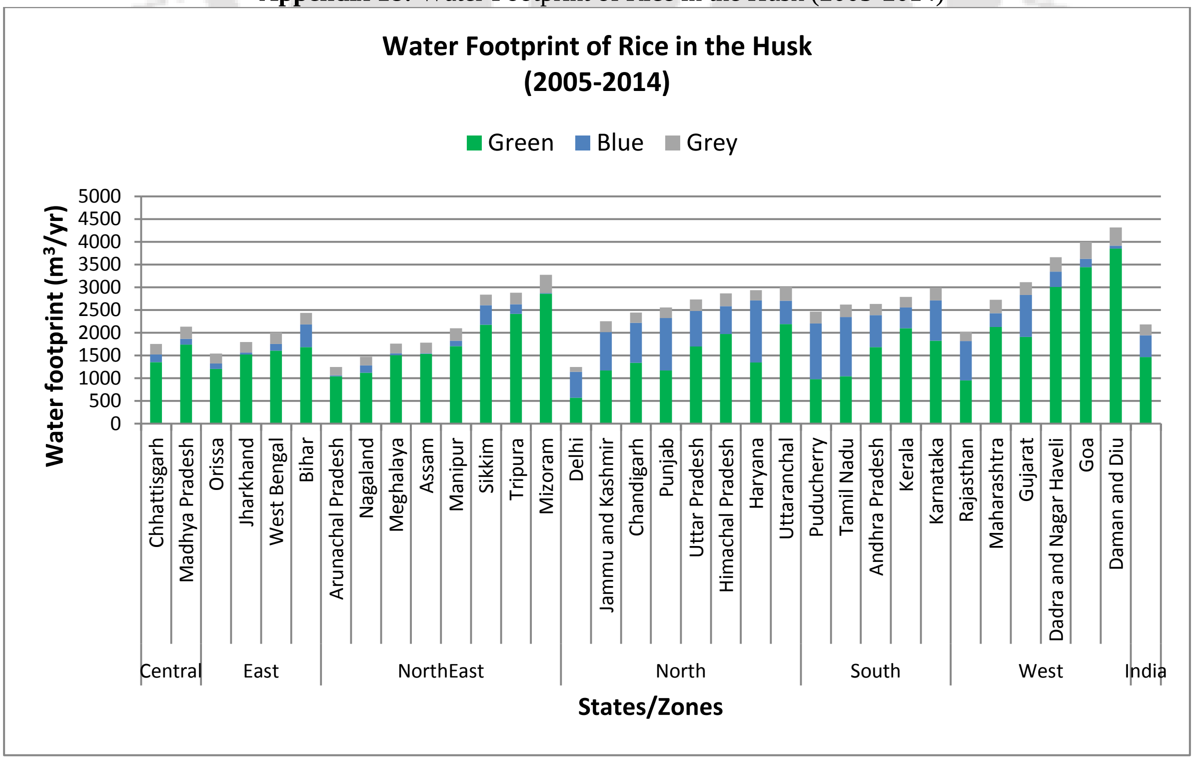
Appendix 16: Water Footprint of Other Vegetable Oil (1996-2005)



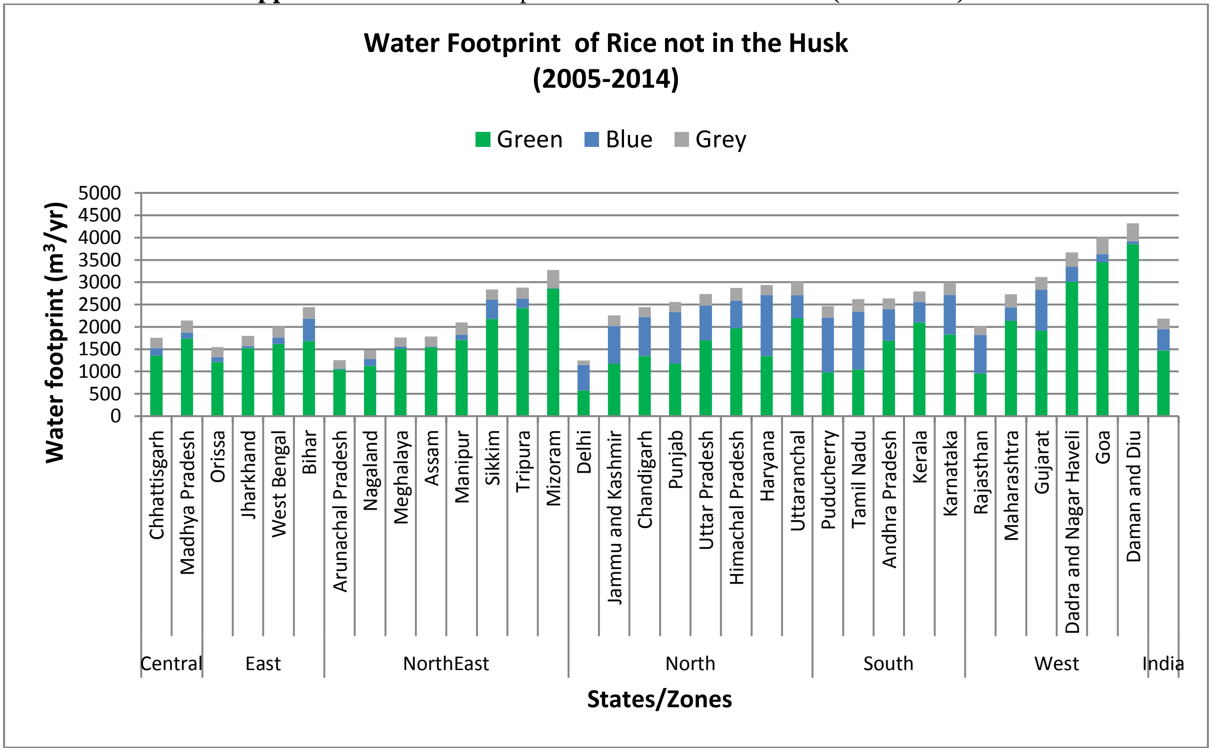
Appendix 17: Water Footprint of Oil cakes (1996-2005)



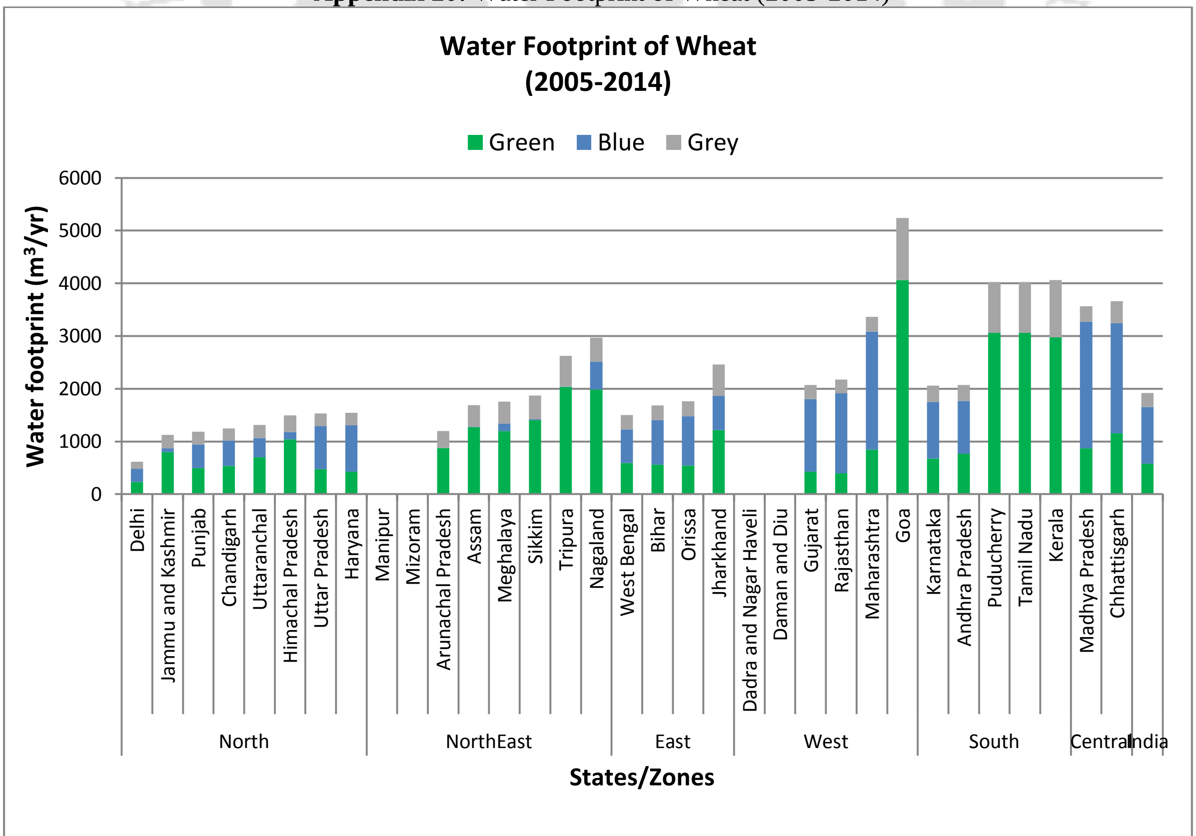
Appendix 18: Water Footprint of Rice in the Husk (2005-2014)



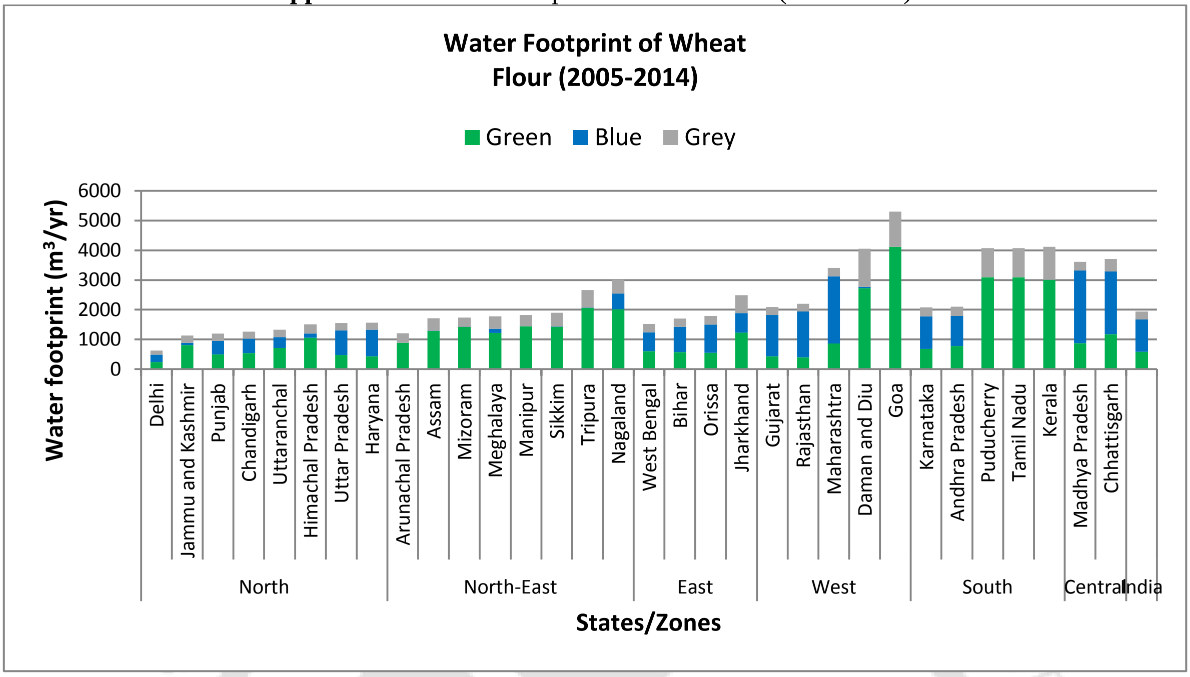
Appendix 19: Water Footprint of Rice not in the Husk (2005-2014)



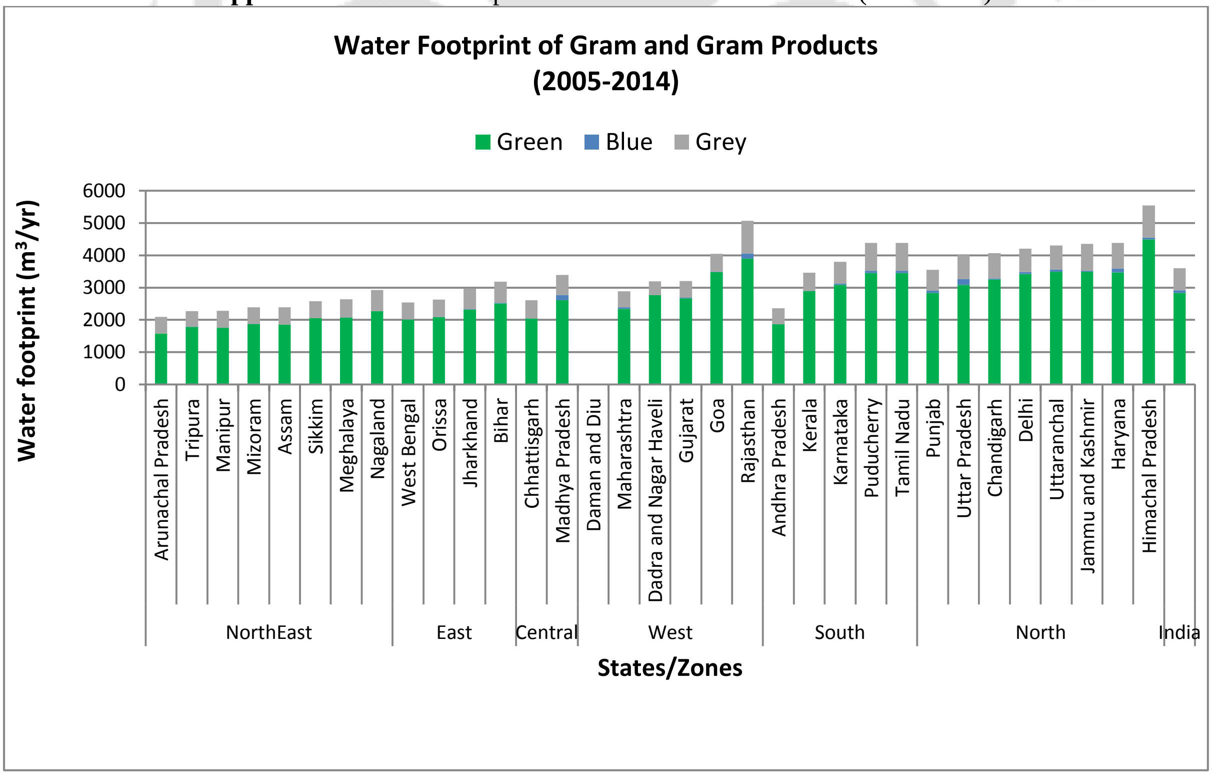
Appendix 20: Water Footprint of Wheat (2005-2014)



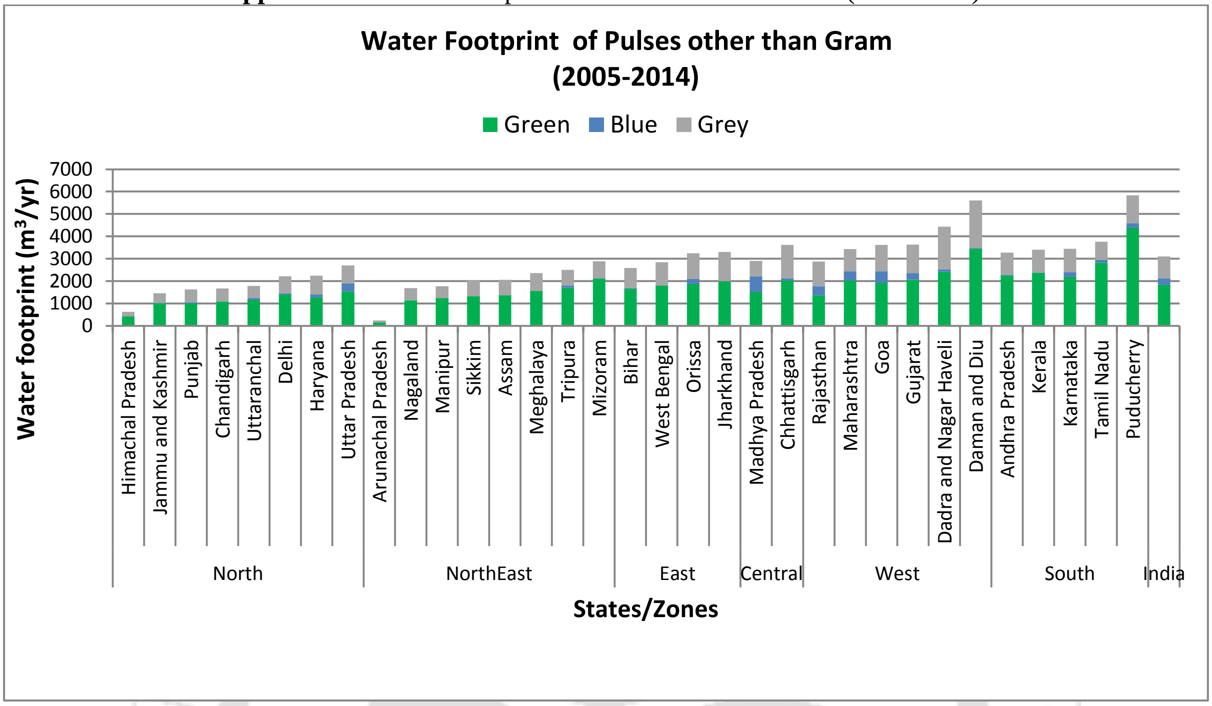
Appendix 21: Water Footprint of Wheat Flour (2005-2014)



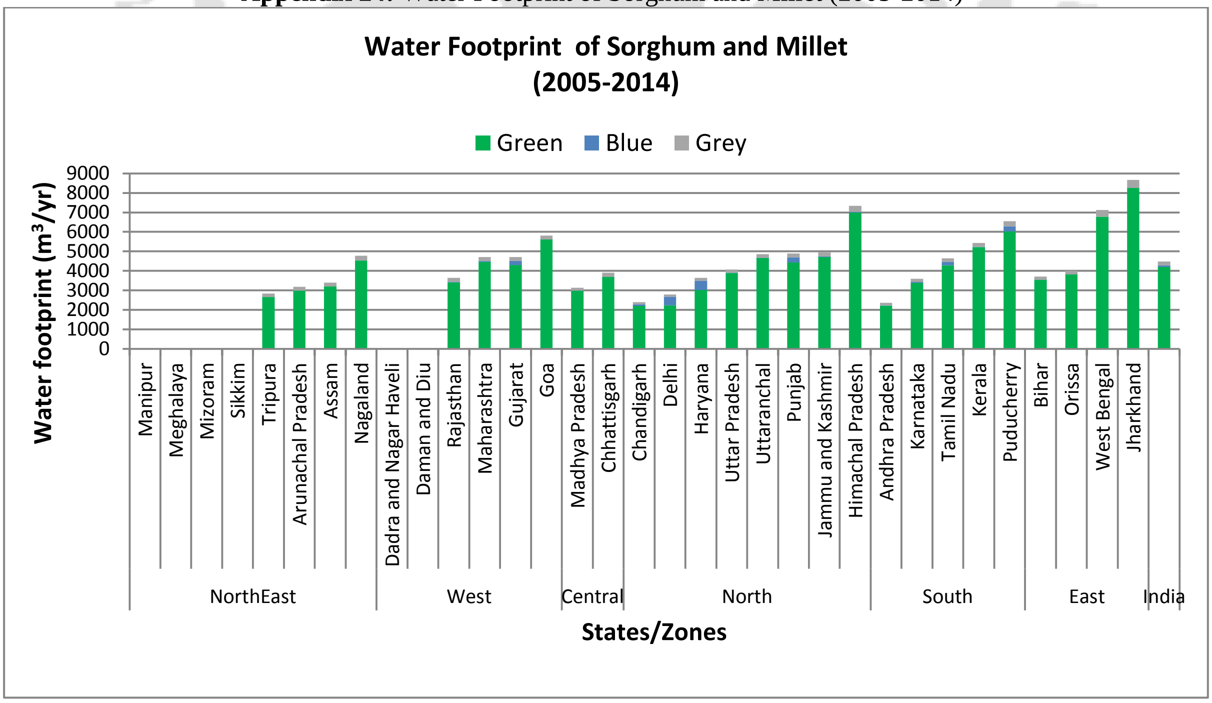
Appendix 22: Water Footprint of Gram and Gram Products (2005-2014)



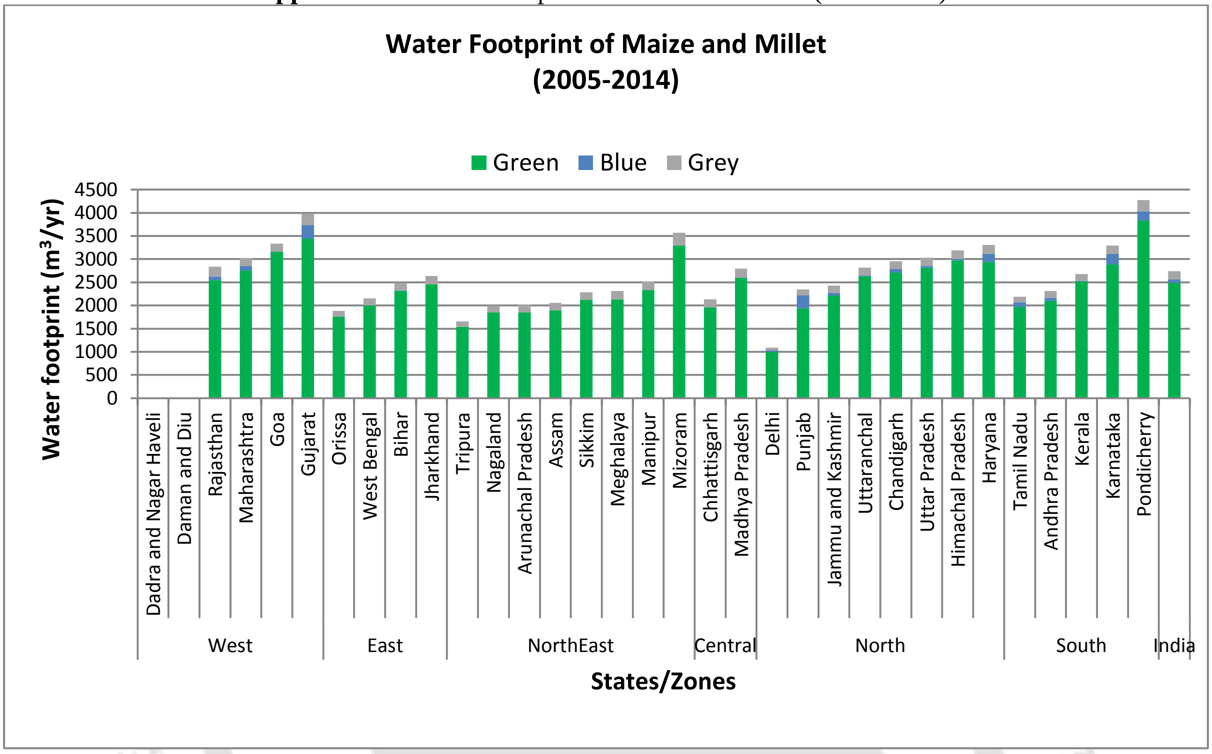
Appendix 23: Water Footprint of Pulses other than Gram (2005-2014)



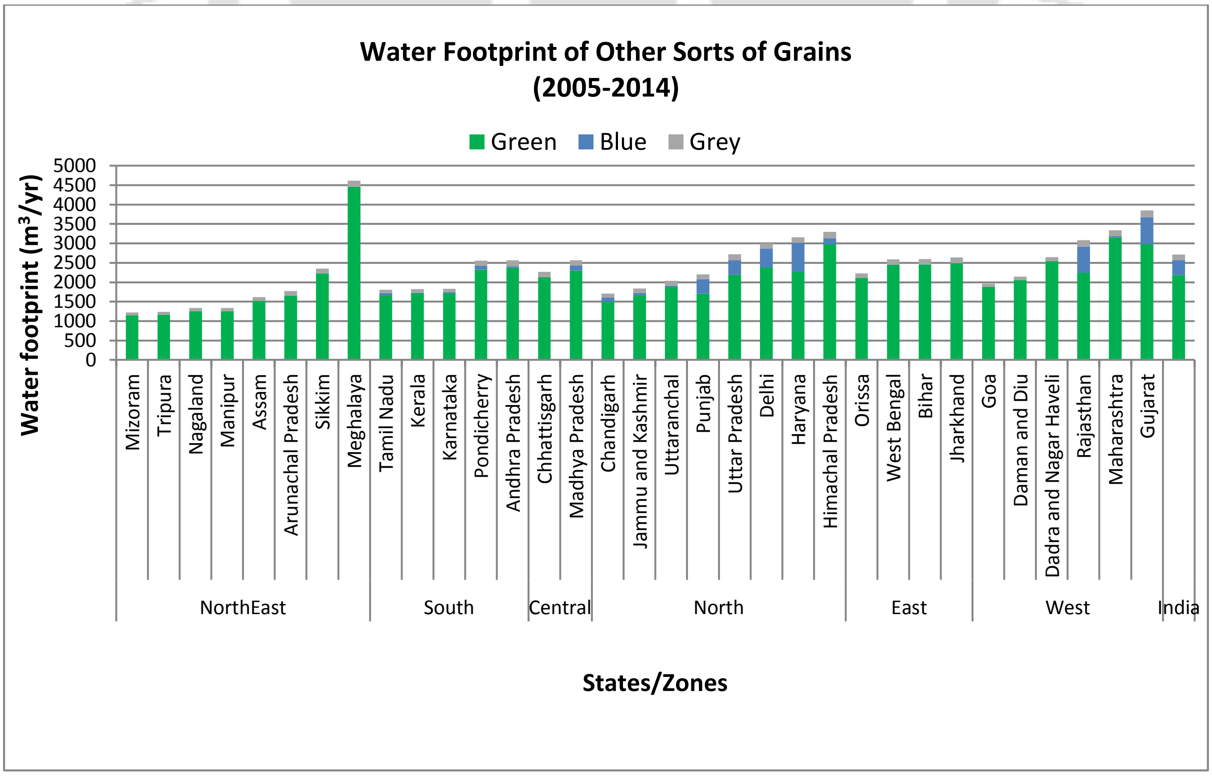
Appendix 24: Water Footprint of Sorghum and Millet (2005-2014)



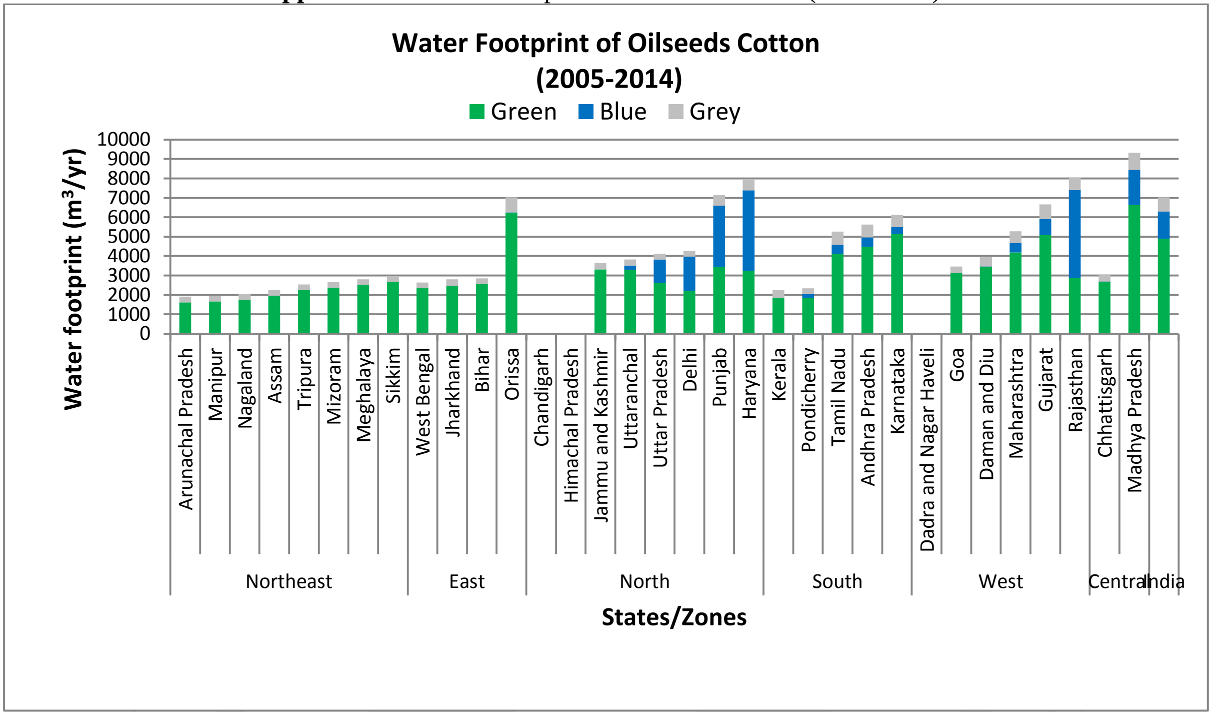
Appendix 25: Water Footprint of Maize and Millet (2005-2014)



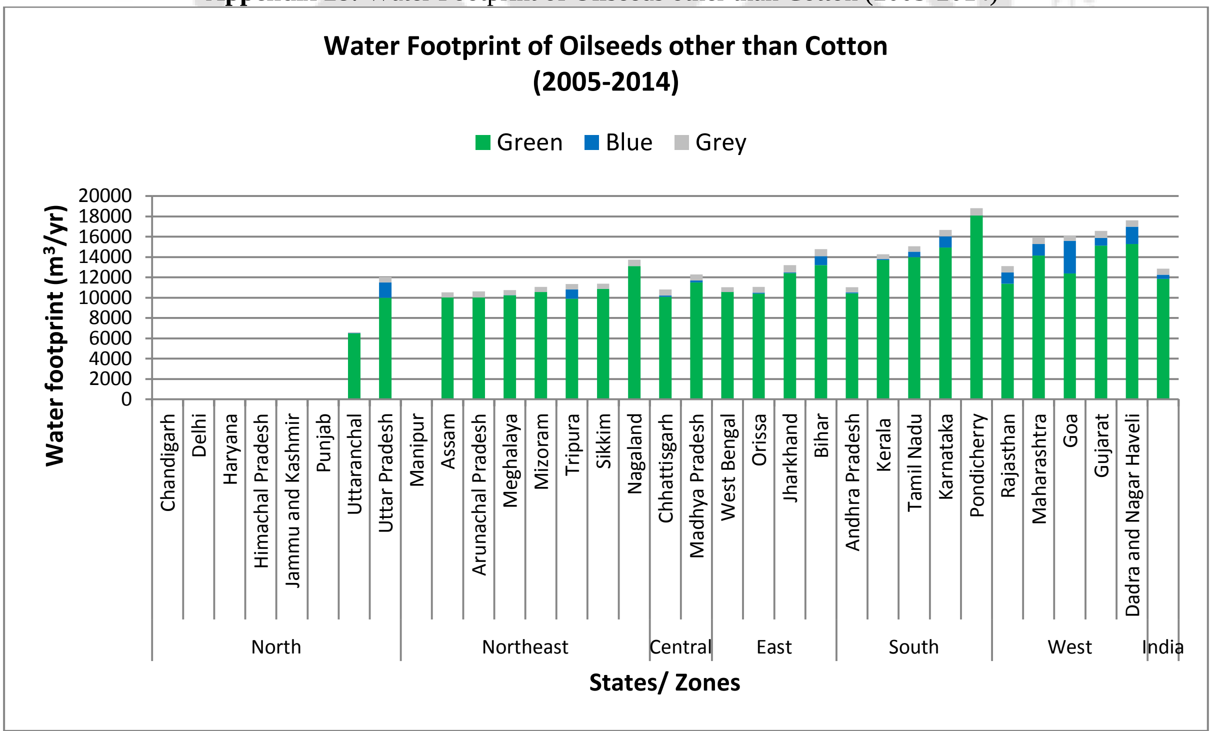
Appendix 26: Water Footprint of Other Sorts of Grains (2005-2014)



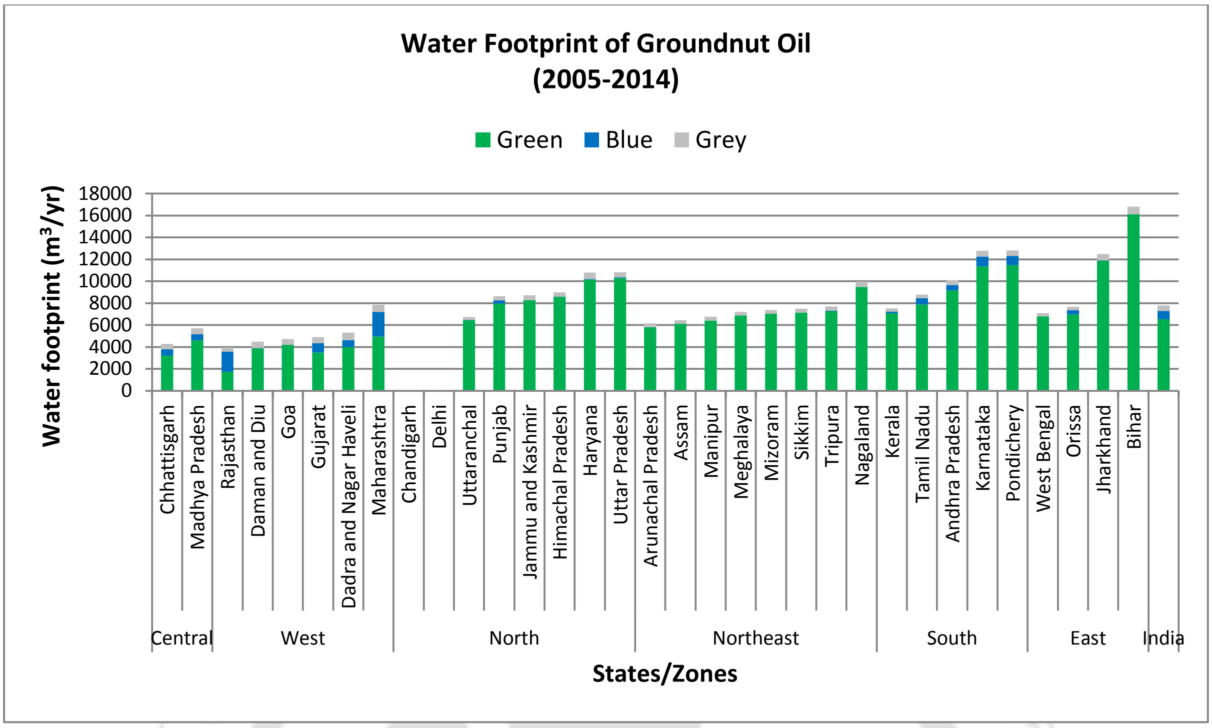
Appendix 27: Water Footprint of Oilseeds Cotton (2005-2014)



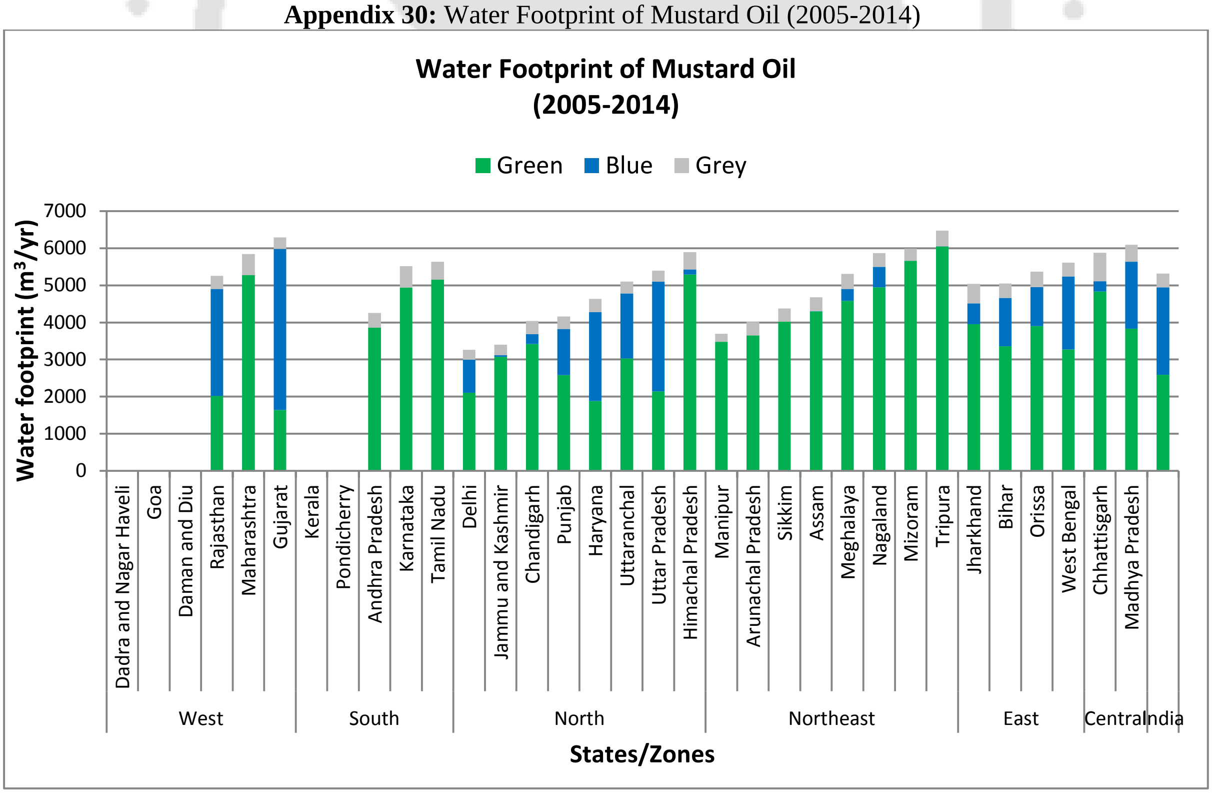
Appendix 28: Water Footprint of Oilseeds other than Cotton (2005-2014)



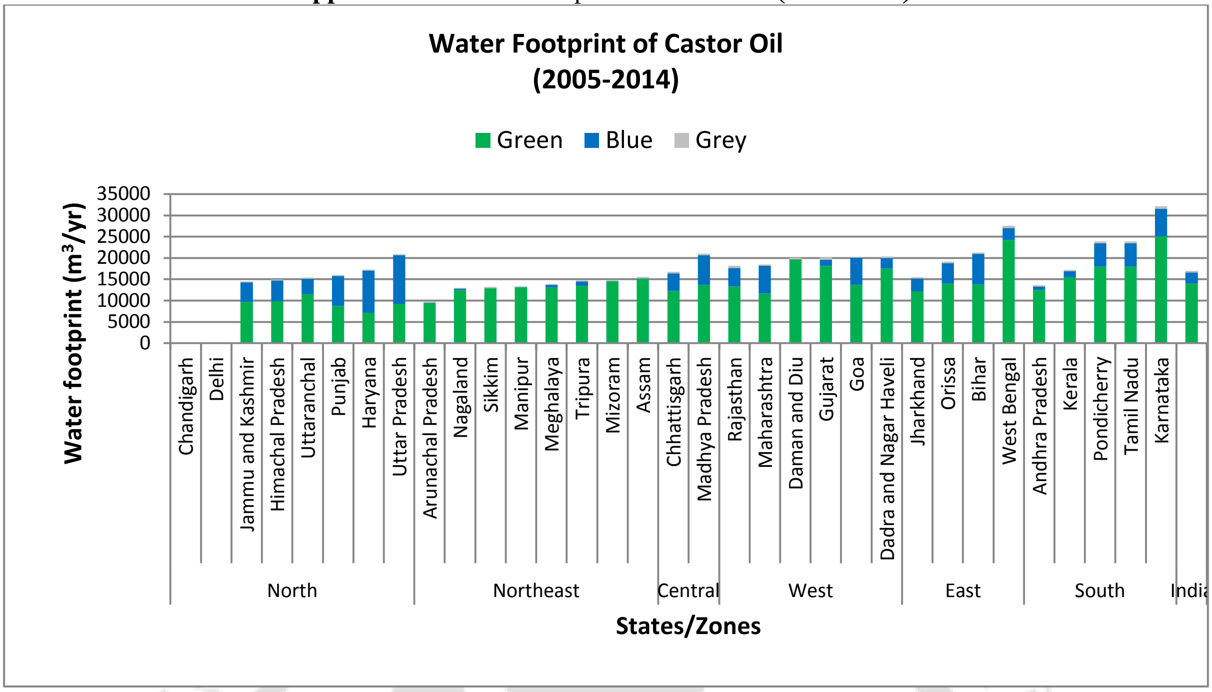
Appendix 29: Water Footprint of Groundnut Oil (2005-2014)



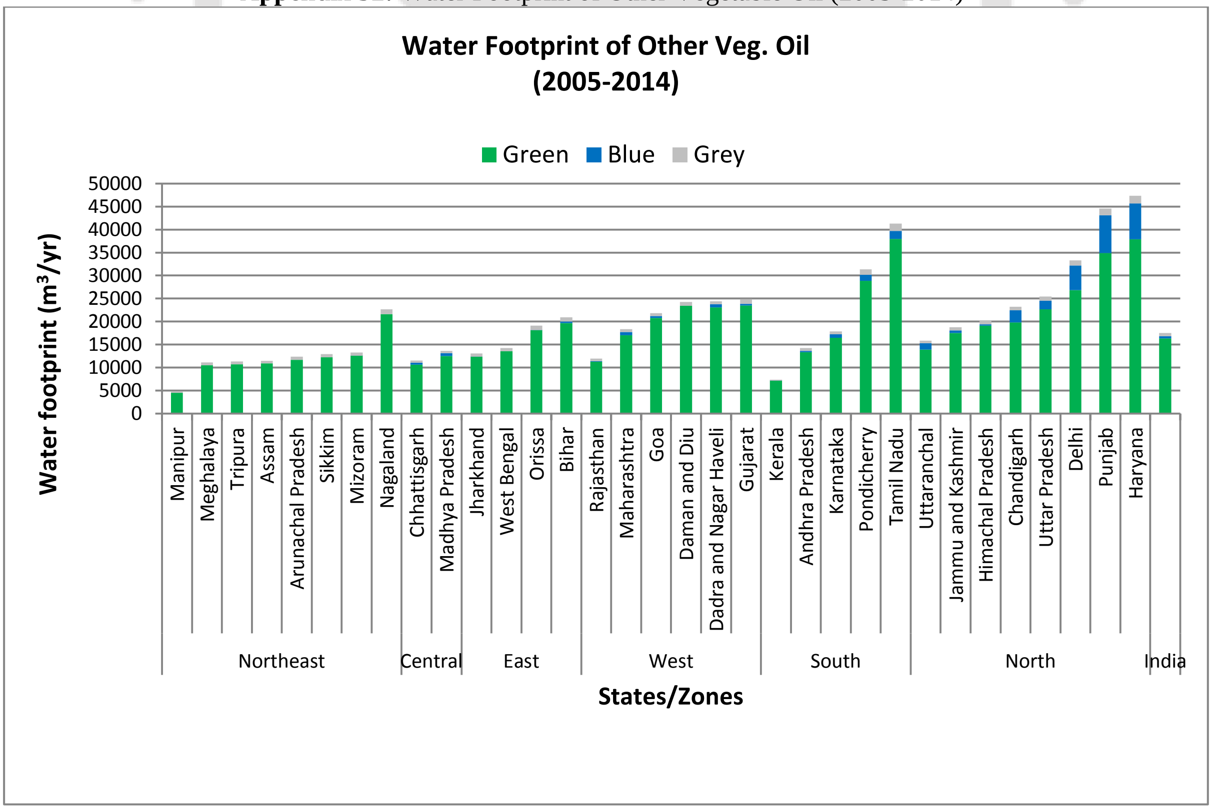
Appendix 30: Water Footprint of Mustard Oil (2005-2014)



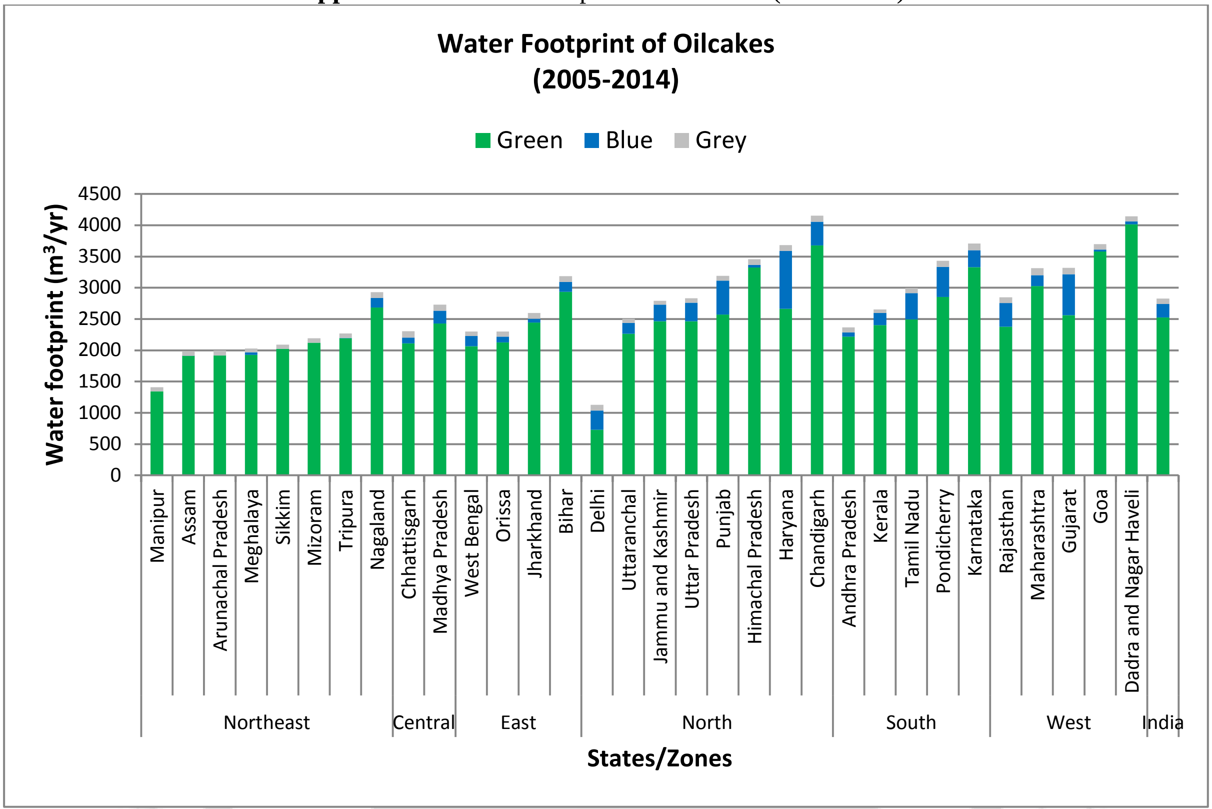
Appendix 31: Water Footprint of Castor Oil (2005-2014)



Appendix 32: Water Footprint of Other Vegetable Oil (2005-2014)



Appendix 33: Water Footprint of Oil cakes (2005-2014)



Appendix 34: Inter-state VW-flows embedded in Food Grains (in GL) (1996-1997)

Food Grains (1996-1997)		**Exported from**																			
		AP	Assam	AR	Bihar	Chandigarh	Delhi	Gujarat	Haryana	Karnataka	Kerala	MP	Maharashtra	Orissa	P & K	Punjab	Rajasthan	TN	UP	WB	Total
Exported to	AP				5.21		85.34	0.09		0.01	-2.32	3.15	-2.58			5.42	1.20	-0.03	2.74	0.04	98.27
	Assam	-27.59			-0.02		-0.01		-0.05				-3.51	-0.48		-2.14				-8.03	-41.83
	Bihar	-0.71							0.01							1.10	-0.04		-0.05	1.24	1.56
	Chandigarh	-0.57																			-0.57
	Delhi		0.26		-0.01				-0.46				-0.04			-9.64	-0.36		-1.16	0.04	-11.37
	Goa																		0.02		0.02
	Gujarat						120.96		21.71			1.07			0.01	43.43	3.40	0.32	0.02		190.93
	Haryana															3.20			0.20	3.63	7.02
	HP								-1.04										0.08		-0.96
	J & K															-2.54	-0.20		-4.14		-6.89
	Karnataka	0.76			0.03	0.00	2.56		3.00							34.66	0.50	0.17	2.25	0.05	43.99
	Kerala	10.11					0.13		6.86	2.94		25.52	4.35		0.96	5.72		0.24	1.15	8.38	66.36
	MP	-1.50											-3.50				4.26			0.03	-0.72
	Maharashtra	0.00			74.34		18.24	1.44	0.17		-7.80	0.49				39.80	9.21		18.49	0.00	154.38
	Manipur												-26.36								-26.36
	Meghalaya	-0.22																			-0.22
	Nagaland	-1.30	1.28						0.02									-0.58			-0.59
	Orissa	-5.33										-38.20				7.34		-0.48		0.22	-36.45
	Punjab								-2.85										-0.05		-2.91
	Rajasthan							-0.03	4.69			38.65				217.24		2.41			262.95
	TN	-3.88			4.46		122.04	0.01	26.64		-0.48	-0.24	-1.43			135.92	24.40		-0.57		306.89
	Tripura								0.00							1.27				0.02	1.28
	UP								-0.16			12.05				125.21					137.11
	WB	-21.58		0.01	-2.04		0.01			-0.06		-4.64	-3.83			1.06					-31.08
	Total	-51.81	1.54	0.01	81.96	0.00	349.27	1.52	58.51	2.89	-10.60	37.86	-36.90	-0.48	0.97	607.05	42.37	2.05	18.97	5.62	1110.79

Appendix 35: Inter-state VW-flows embedded in Food Grains (in GL) (1997-1998)

Food Grains (1997-1998)		**Exported from**															
		AP	Assam	Bihar	Delhi	Gujarat	Haryana	Karnataka	Kerala	MP	Maharashtra	Punjab	Rajasthan	TN	UP	WB	Total
Exported to	AP				111.13		0.18			2.40	-0.30	3.15	-0.07		14.53		131.03
	Assam	-12.56		-0.07	-0.20		-19.03					-1.28	-0.61		-3.46	-5.71	-42.92
	Bihar							0.09					-2.25	0.51		0.86	-0.78
	Chandigarh											0.00	0.00				0.00
	Delhi						-5.26			0.93	1.79	-3.79	0.31				-6.02
	Goa						259.57						0.00				259.57
	Gujarat						0.00	-0.12		1.24			0.85	1.41			3.38
	Haryana				1.21							0.01	0.58		5.08	-0.07	6.82
	HP												1.72				1.72
	J & K				-0.02		-7.28					-2.68	-0.11		-0.52		-10.62
	Karnataka	1.60			13.99		0.05					0.45	1.47				17.56
	Kerala	3.47			14.10		2.15		67.08		0.49	6.91	0.12	0.77	0.55		95.63
	MP											6.75	-5.29				1.46
	Maharashtra				17.22	-0.04				1.40		0.80	0.11		0.04		19.52
	Nagaland	-1.04													-0.20		-1.24
	Orissa	53.47								-2.43					0.02	0.11	51.17
	P & K													0.13		0.13	0.26
	Punjab						-0.01						-2.60		-1.13	-0.18	-3.92
	Rajasthan				0.00		33.79				0.02	107.49			0.04		141.34
	TN	4.44	0.14		260.03	-0.01	18.10	0.38		3.05	-1.84	50.86	9.78		0.89		345.81
	Tripura														-0.01	0.03	0.03
	UP	-10.20			0.09		-1.53					72.14	-2.81			0.28	57.97
	WB	-4.55		-2.91	0.08	-1.01	-8.78				0.00	3.85	-3.56		-0.42		-17.31
	Total	34.62	0.14	-2.98	417.62	-1.06	271.94	0.35	67.08	6.60	0.17	244.66	-2.35	2.82	15.41	-4.55	1050.47

Appendix 36: Inter-state VW-flows embedded in Food Grains (in GL) (1998-1999)

Food Grains (1998-1999)		**Exported from**															
		AP	Assam	Bihar	Delhi	Gujarat	Haryan a	Karnata ka	MP	Mahara shtra	Punjab	Rajasth an	TN	Tripura	UP	WB	Total
Exported to	AP				-27.38		-0.08		1.03						1.15		-25.28
	Assam				-10.91		-0.01		-0.77			-3.39		-0.01	-4.20	-5.33	-24.62
	AR	-0.82					-0.17								-5.57		-6.57
	Bihar				-0.06			0.04	0.23			-0.17			0.71	0.00	0.74
	Chandigarh	-0.01					-3.71										-3.72
	Delhi	0.12	0.02				-1.21			-5.98		-0.17			-0.01		-7.23
	Gujarat							0.02									0.02
	Haryana										0.06	0.01			0.37		0.44
	HP											-0.02					-0.02
	J & K										-0.10	-1.95					-2.05
	Karnataka	-0.10			0.18										-0.01		0.08
	Kerala	1.07							4.81		0.94		1.49		0.05		8.36
	MP																0.00
	Maharashtra				-0.28			-0.06			0.27	-0.27			0.03		-0.30
	Manipur		-0.05														-0.05
	Mizoram			0.09													0.09
	Nagaland		-0.04														-0.04
	Orissa	-1.85														0.02	-1.83
	Punjab				-0.01							-0.42			-0.04		-0.46
	Rajasthan									-0.87	0.23				0.16		-0.48
	TN	1.46		1.74	31.17	-0.06	-0.15				0.06	-14.33			13.51		33.39
	Tripura		0.77						1.07						-0.02		1.82
	UP						5.91	-0.01	0.01			-1.53				-0.01	4.37
	WB	-0.84	0.89	-1.06	-1.48		0.03		-3.82			-0.08			4.94		-1.42
	Total	-0.97	1.59	0.77	-8.77	-0.06	0.62	-0.01	2.55	-6.85	1.47	-22.33	1.49	-0.01	11.10	-5.33	-24.75

Appendix 37: Inter-state VW-flows embedded in Food Grains (in GL) (1999-2000)

Food Grains (1999-2000)		**Exported from**																
		AP	Bihar	Chandigarh	Delhi	Gujarat	Haryana	Karnataka	Kerala	MP	Maharashtra	Orissa	Punjab	Rajasthan	TN	UP	WB	Total
Exported to	AP				-3.06					0.36	4.68							1.97
	Assam		173.43		339.84		82.34							-0.54		240.26	85.37	920.70
	AR															-0.31		-0.31
	Bihar							0.86		64.57		-0.34			0.01		0.99	66.09
	Chandigarh															0.00		0.00
	Delhi	34.66									1110.45			1.93			6.50	1153.55
	Gujarat														0.02			0.02
	Haryana															0.07		0.07
	J & K										0.35			2.25				2.60
	Karnataka				95.37		1044.28				-6.02		-1.49	0.01		2188.69	8659.38	11980.21
	Kerala					0.00	0.00							0.01				0.00
	MP	0.23					2.70											2.92
	Maharashtra					0.00				-0.14	234.96	0.06						234.88
	Orissa									144.77			1.74				0.03	146.55
	Punjab										78.85					-0.17	0.01	78.70
	Rajasthan	0.11																0.11
	TN				2.50	1.76			-0.03					32.79		11.68		48.70
	Tripura																0.46	0.46
	UP				21.29						95.62			0.25				117.16
	WB	12.73	168.83	0.34	3.16	-0.02	0.01				187.76			-0.49		4.77		377.07
	Total	47.73	342.25	0.34	459.09	1.73	1129.32	0.86	-0.03	209.56	1706.65	-0.28	0.25	36.20	0.03	2444.98	8752.75	15131.44

Appendix 38: Inter-state VW-flows embedded in Food Grains(in GL) (2000-2001)

Food Grains (2000-2001)		Exported from																					
		AP	Assam	Bihar	Chandigarh	Delhi	Gujarat	Haryana	J & K	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	P & K	Punjab	Rajasthan	TN	Tripura	UP	WB	Total
Exported to	AP	0.00	0.35	11.74		-1.66		4.00		4.82		-18.80	-0.87				117.48	1.86			45.28		164.18
	Assam	-37.81		-1.43	-9.01	-92.59		-120.05		-20.18		-25.15	-8.40	0.04			-346.20	-5.33	-9.88		-173.66	-10.49	-860.13
	AR					0.39																	0.39
	Bihar							-277.93		-157.91		2.71	-0.63		0.01		171.48		-2.63		-8.86	10.89	-262.86
	Delhi	-3.04		2.17				-113.19				2.58	0.02		0.06		-1.09	-3.92			0.14		-116.27
	Goa												2.94					0.00					2.94
	Gujarat	12.46		5.43		0.46		-65.58		4.88	0.64	3.23	1.37				694.32	1.25	1.21		0.64	6.72	667.01
	Haryana	2.49															86.35	0.06			4.14	2.36	95.41
	HP							-2.98															-2.98
	J & K				-0.37			-18.77									-8.37	-0.71			-0.13		-28.36
	Karnataka	168.08			4.19	51.99		-10.36				1.02					409.21	0.83	-7.65		107.78		725.08
	Kerala	423.19			0.11	456.44	0.00	24.63		-0.59			0.63				160.15	2.01	5.03		66.90		1138.52
	MP	0.32		-0.02	-1.70		-0.44	110.33					-0.96		1.45		589.10	3.34			-5.76		695.67
	Maharashtra	0.41			12.85	-2.91		256.40							0.01		1909.02	2.27			20.54		2198.58
	Manipur		-0.01																				-0.01
	Meghalaya	-0.08	0.01																				-0.07
	Nagaland	-57.27	-1.63	-0.04				-0.08													-0.49	-0.38	-59.89
	Orissa	-19.84	0.02		-2.06	3.47		-64.90				-27.35	-8.19				-138.02				-25.33	1.16	-281.04
	P & K							0.24					0.00						18.04			0.95	19.24
	Punjab	1.14				-0.01		-13.44		-1.37			0.00					-0.08			-1.96	-0.05	-15.77
	Rajasthan	-3.02				0.47		-131.51					-0.03				518.74		0.04		1.83		386.51
	TN	-346.33			-0.85	485.29		49.73		-9.65	-0.28	8.70	-4.92				365.98	103.23		50.64	349.02		1050.54
	Tripura		48.95	-14.23								24.26					3.46				3.43	0.01	65.88
	UP	-0.16	0.26			1.16		-58.38	0.28	-2.32						0.21	70.22	-1.35				-0.11	9.81
	WB	-4.15		-4.58	-0.61	-6.06		-495.03	-0.04	-18.76		-10.61	-1.76				-155.52	-1.63			-3.46	-1.72	-703.92
	Total	136.38	47.96	-0.97	2.54	896.42	-0.44	-926.89	0.24	-201.08	0.36	-39.42	-20.79	0.04	1.53	0.21	4446.31	101.84	4.16	50.64	380.05	9.35	4888.45

Appendix 39: Inter-state VW-flows embedded in Food Grains (in GL) (2001-2002)

Food Grains (2001-2002)		**Exported from**																			
		AP	Assam	Bihar	Chandi garh	Delhi	Goa	Gujarat	Haryan a	Karnata ka	Kerala	MP	Mahara shtra	Orissa	Punjab	Rajasth an	TN	Tripura	UP	WB	Total
Exported to	AP					166.19			217.32	2.39		-11.65	-5.65		1478.97	8.64			142.26	14.64	2013.10
	Assam	-73.62		-0.73		-77.45		-0.24	-146.07	-1.21		-20.92	-0.02		-359.41	-20.38	-3.96	-0.09	-48.09	-5.04	-757.25
	AR												0.00				0.40				0.40
	Bihar	-0.43							-17.33	73.09		-149.93	-10.58	5.13	244.40	-7.78	-3.50		0.50	-0.15	133.42
	Chandigarh									-8.70									-11.30		-20.01
	Delhi	5.25	0.02	0.16				-0.03	-34.55	2.67			2.56	0.95	1.98	-143.78					-164.75
	Goa	0.16	0.00																		0.16
	Gujarat	21.93			14.96	119.99		14.56	706.44	258.15	0.02	1.79	-34.75	2.80	3388.61	19.27	4.98		41.18	16.87	4576.81
	Haryana	0.30		0.82						2.61		0.41	0.07		0.90	-0.78			2.41		6.73
	HP												-719.53			-3.40					-722.92
	J & K								-147.17						-7.44				-21.40	-0.06	-176.07
	Karnataka	285.82				195.35	-0.24	0.00	132.75				-23.38		459.01	1.76	-17.93		140.78		1173.92
	Kerala	191.17				12.48		0.02	194.23	16.25	2.92		30.89		230.29	5.56	20.70		224.18	32.13	960.82
	MP	-0.16			-0.58				597.76		-1.59		1.25	1.32	1835.77	27.42			109.19	6.90	2577.28
	Maharashtra	0.92				7018.87			531.49				76.07	6.65	3476.69	9.27			147.52	62.51	11330.00
	Nagaland	-39.37	8.49																	1.02	-29.86
	Orissa	-2.97	63.74	0.61					9.88			-52.34			79.68	-0.01			-3.71	0.30	95.20
	P & K																			4.52	4.52
	Punjab	25.20		0.06				-0.16		2.44		0.05	-284.28			-11.34			-24.99	-3.80	-296.83
	Rajasthan	-0.10			5.51				338.44				2.24		457.81				2.45		806.35
	TN	-355.99		-0.09		1863.19		0.69	289.29	210.95		1.45	66.31		481.79	105.50			710.26	18.71	3392.07
	Tripura	18.36	72.21	-0.38					1.08						8.97				14.34	1.48	116.04
	UP	-4.67		1.44					-3.76	-0.70			-20.81	0.26	3.19	-72.97				12.22	-85.80
	WB	27.83	3.11	-4.80	0.80	40.50		-0.17	-161.30	13.21		-74.79	45.76	3.18	68.18	-1.87	-0.09		29.03		-11.42
	Total	99.65	147.57	-2.91	20.70	9339.10	-0.24	14.68	2508.50	571.14	1.35	-305.93	-873.85	20.30	11849.40	-84.90	0.60	-0.09	1454.61	162.24	24921.91

Appendix 40: Inter-state VW-flows embedded in Food Grains (in GL) (2002-2003)

Food grains (2002-2003)		**Exported from**																		
		AP	Assam	Bihar	Chandigarh	Delhi	Gujarat	Haryana	Jammu	Karnataka	Kerala	MP	Maharashtra	Orissa	Punjab	Rajasthan	TN	UP	WB	Total
Exported to	AP			0.56		-5.15		-348.30		3.43	-0.68	24.44	-29.91	53.07	129.49	19.71	6.11	600.18	-151.22	301.72
	Assam	-65.02		-1.34	-3.51	-74.49	-0.01	-309.72		-13.30		-21.84	-11.81		-835.68	-0.65		-31.97	-14.59	-1383.94
	AR							-11.71												-11.71
	Bihar	-0.50			0.79			-13.87		-60.99		12.04	-3.14	30.70	-11.26	-3.15	62.53	-3.49	1.86	11.51
	Chandigarh																	-0.71		-0.71
	Delhi	150.09		3.34				-36.90				7.63	5.87	2.84	2.07	-41.67		-30.69	-1.45	61.12
	Gujarat	83.88		5.96	9.90			856.45		-0.94		14.09	-222.64		776.35	5.08	165.59	341.36	-24.47	2010.60
	Haryana			0.78								-0.17	7.76			-0.02		30.27	1.71	40.34
	HP												-5286.26	17.45	0.58			-2.65		-5270.87
	J & K							-72.02							-4.74			-39.50		-116.27
	Karnataka	-20.38		2.33		-11.03	0.11	63.82			-0.12	33.31	-11.85		465.65	0.98	1.98	363.05	-26.59	861.26
	Kerala	407.82				0.69	0.89	208.87		1.85			141.59	0.15	14.73	10.58	3.47	460.44	64.57	1315.66
	MP			5.60			2.31	1197.49					105.80		-16.90	9.13		1119.57		2422.99
	Maharashtra	-0.08		3.83	6.19	-26.62	2.47	778.88	6.56			106.17		1.52	182.07	10.82		3216.59	-7.42	4280.95
	Manipur		0.01																	0.01
	Nagaland	-47.15	3.96																-1.86	-45.05
	Orissa	-1.87		8.83				9.55				-1.38	-15.90		-2.05			-66.08	12.89	-56.02
	Punjab	146.58		0.14				-1.60					-1282.03					-15.57	-5.59	-1158.06
	Rajasthan							123.46		-0.01			400.58		4.00			20.82		548.85
	TN	-350.41	0.06	-0.64		-196.75	39.06	234.85		15.91	-0.10	2.56	696.69	7.44	-45.04	443.96		1224.30	-97.02	1974.88
	Tripura		86.08	-11.87				1.10									51.54	48.49	-181.90	-6.57
	UP	-3.05	17.33	1.67		-0.06		-14.36					-216.86	1.42	0.73	-35.79			-26.20	-275.17
	WB	-188.75	0.02	-11.63		-2.85		-151.66		-20.53		-58.23	-68.35	21.50	-243.19	-24.10		-149.33	-2.62	-899.72
	Total	111.15	107.45	7.56	13.37	-316.27	44.83	2514.33	6.56	-74.60	-0.90	118.60	-5790.44	136.10	416.80	394.89	291.21	7085.07	-459.90	4605.81

Appendix 41: Inter-state VW-flows embedded in Food Grains(in GL) (2003-2004)

Food Grains (2003-2004)		Exported from																				
		AP	Assam	Bihar	Chhattisga rh	Chandigar h	Delhi	Gujarat	Haryana	Karnataka	Kerala	MP	Maharasht ra	Nagaland	Orissa	Punjab	Rajasthan	TN	Tripura	UP	WB	Total
Exported to	AP	0.00		0.23		0.22	-1.85		537.94	-21.99	-1.13	33.68	-0.63		20.66	1363.54	62.39	1.21		23.39	2.02	2019.70
	Assam	-45.87				-5.50	-76.24		-396.48			-15.33	-8.65		0.21	-774.62	-304.12			-114.05	-3.92	-1744.57
	AR								-212.15													-212.15
	Bihar								-6.31			0.60	-2.96			304.38	-193.03			-0.94	-1.07	100.67
	Chandigarh								-16.82											-0.58		-17.40
	Delhi	15.63										1.28	1.16					1.94			0.77	20.78
	Goa								39.32						0.50	24.32	7.76			1.18		73.08
	Gujarat					5.22	2.41		787.37		0.03	1.62		0.06		2703.04	97.12	2.92		5.44		3605.23
	Haryana	1.77																		4.89		6.66
	J & K								-3.43			1.75				-0.69	-9.13			-82.67		-94.17
	Karnataka	8.54				3.69	-14.85		151.53			104.53			7.05	966.75	94.01			42.53		1363.79
	Kerala	319.20					-5.63		343.86			53.96	12.73		26.98	366.72	53.05	-0.12		275.75		1446.51
	MP	1.34		0.02					2233.51				-0.04			1966.38	201.14			-3.89		4398.47
	Maharashtra					0.69	-23.13	-0.21	2085.72			38.86	0.00	3.22	0.00	1001.63	232.68	0.77		33.66		3373.89
	Manipur															-55.80						-55.80
	Mizoram														-0.11					-0.01		-0.12
	Nagaland		-1.07						-56.42							-2.06				0.03	-0.50	-60.02
	Orissa	-0.05						-0.30	35.97			-4.82	-24.04	0.02		-135.25	-254.01			-8.31	0.22	-390.58
	Punjab	2.70							-1.08			0.44	-0.29		1.98			-1.04		-3.07	-0.13	-0.48
	Rajasthan								374.37				-0.03			573.51					1.47	949.33
	TN	-241.70			1.55		-177.43		495.49	-4.79	-307.20	6.30	-12.74	0.01	2.79	535.86	11.54			482.50		792.19
	Tripura		121.55				0.47		2.21							12.90	5.06			18.49		160.68
	UP	-0.03							-10.10							307.20	-160.44				-0.04	136.60
	WB	-59.22	0.62	-16.16			-52.96		-67.77			-17.50	-13.60	0.00	-0.58	83.60	-458.82	-6.59	2.58	-44.03		-650.43
	Total	2.31	121.10	-15.91	1.55	4.31	-349.21	-0.52	6316.77	-26.77	-308.29	205.37	-49.08	3.31	59.49	9241.41	-614.78	-0.90	2.58	630.32	-1.18	15221.88

Appendix 42: Inter-state VW-flows embedded in Food Grains (in GL) (2004-2005)

Food Grains (2004-2005)	**Exported from**																						
Exported to	AP	Assam	Bihar	Chhattisgarh	Chandigarh	Delhi	Gujarat	Haryana	Jharkhand	Karnataka	Kerala	MP	Maharashtra	Manipur	Nagaland	Orissa	Punjab	Rajasthan	TN	Uttaranchal	UP	WB	Total
AP				259.13	0.65	-11.25		559.05		-29.00	-0.39	-31.89	-4.42			38.01	360.79			6.88	544.00		1691.56
Assam	-50.12			-18.07	-15.98	-27.84		-295.40					-18.56	0.16		0.20	-1239.66			-26.56	-103.14	-0.09	-1795.06
AR								-360.71												-16.11	-12.74		-389.56
Bihar	-4.56			7.28	-0.57			-11.83				-0.04					386.26	-1.61		-1.15	-23.73	7.62	357.68
Chhattisgarh								111.84									397.26					-0.02	509.07
Chandigarh																				-2.55	-2.60		-5.15
Delhi	-11.08			1.76				-13.90		0.89		4.85	-11.50	-1.78		9.78	7.09		-3.64		14.91	1.90	-0.72
Goa				2.83		5.30	0.01	38.51					1.40				16.93						64.98
Gujarat	6.72			21.87		104.84		389.63				-23.19	12.18	17.75		21.78	1093.28	0.94		15.10	40.73		1701.65
Haryana	1.88					1.13												0.53			8.78		12.32
J & K				6.51				-13.72								1.26	-11.48			-21.76	-70.02		-109.21
Jharkhand				6.58	-0.51			45.92					-1.70			8.42	278.21				-74.73	4.54	266.73
Karnataka	32.97			151.96	9.28	-6.13		49.70				-33.35	-0.80	28.33		0.10	1467.29	5.17		9.08	207.60		1921.20
Kerala	376.53			100.55		-1.14		288.36				37.94	5.16				1039.01	43.03	-0.04	0.26	588.25		2477.90
MP				5.64	-1.17			992.38					0.24			0.41	3347.14				1.78		4346.43
Maharashtra	2.40			81.50	1.02	35.09	-0.02	2169.79		-2.95		1.98	0.00			2.34	4421.69			5.98	11.78	2.41	6733.03
Nagaland	-12.08	9.33				9.16															-0.55	-3.74	2.13
Orissa	-1.78			-14.38	-2.04	8.65	-1.90	-49.69				-59.40					-122.98				-5.74		-249.27
P & K								222.06															222.06
Punjab	1.89											0.45	0.15							-1.25	-9.47	1.29	-6.94
Rajasthan						30.78	-0.07	57.33				-609.21	-5.53				427.62						-99.09
TN	-295.28		-0.03	199.21		-127.96	-0.15	91.54	0.69	-3.38	-12.68	50.55	-11.74		2.86	21.10	361.80	431.66		13.63	3533.14		4254.97
Tripura		174.08		2.49													9.47				2.18		188.22
Uttaranchal											-39.90						10.09						-29.81
UP	-5.35			0.04		-0.08	-0.22	-14.60					-51.69			-0.20	461.25			-2.20		-0.04	386.90
WB	-100.58	0.07	-7.52	-14.09	-1.42	-11.49	-5.35	-79.29	-3.41	-26.29		-75.96	-31.01	-0.24		19.71	373.82	-1.24		-24.28	-133.52		-122.07
Total	-58.42	183.48	-7.55	800.82	-10.72	9.07	-7.71	4176.96	-2.72	-60.73	-52.98	-737.26	-117.82	44.21	2.86	122.92	13084.90	478.48	-3.68	-44.94	4516.90	13.87	22329.95

Appendix 43: Inter-state VW-flows embedded in Oilseeds (in GL) (1996-1997)

Oilseeds (1996-1997)		Exported from																		
		AP	Assam	Bihar	Gujarat	Haryana	Jharkhand	Karnataka	Kerala	MP	Maharashtra	Orissa	P&K	Punjab	Rajasthan	TN	Tripura	UP	WB	Total
Exported to	AP									-11.65	-45.39	0.87						0.54	1.76	-53.87
	Assam				-0.26						-0.03				-3.60	-0.02			-8.95	-12.87
	Bihar	-0.02	0.13		-0.37						-0.96				-0.39	1.04		-0.01	0.68	0.10
	Delhi	-10.97	2.42								-77.33			-0.35			0.06	0.03		-86.15
	Gujarat	1.61	0.09							24.51	15.32				1.86	1.33	0.20		0.06	44.98
	Haryana	0.29	0.12								0.01			0.66					0.38	1.46
	Karnataka									-0.06	100.09					0.45				100.49
	Kerala					-2.26				0.23	-7.80		-0.06	-2.21		-1.34				-13.44
	MP		0.30								-19.56									-19.26
	Maharashtra	1.22						-0.44	2.84	10.93										14.56
	Meghalaya	0.00									-0.01									-0.01
	Mizoram	0.00																		0.00
	Orissa										-12.27				0.01				2.43	-9.83
	Punjab	0.00		0.33					3.10	0.51	0.07				0.05					4.07
	Rajasthan										0.26			0.00		-0.06				0.19
	TN	0.00				-0.46			0.03	0.33	12.94			-0.08				2.51	1.92	17.19
	Tripura		0.50																	0.50
	UP	0.09				-0.02	0.10				-2.20			0.07	-0.02				1.30	-0.68
	WB	-0.10	0.06	-0.03	-0.73	0.09				-2.77	-10.43			5.34	-6.47			-1.12		-16.17
	Total	-7.86	3.61	0.30	-1.36	-2.66	0.10	-0.44	5.98	22.05	-47.32	0.87	-0.06	3.43	-8.57	1.39	0.26	1.93	-0.42	-28.76

Appendix 44: Inter-state VW-flows embedded in Oilseeds (in GL) (1997-1998)

Oilseeds (1997-1998)		**Exported from**														
		AP	Assam	Bihar	Chandigarh	Delhi	Gujarat	Haryana	MP	Maharashtra	Punjab	Rajasthan	TN	UP	WB	Total
Exported to	AP					0.10			-6.05	-17.92						-23.87
	Assam				0.01	-0.34	-0.56					-0.46	-0.09	-0.19	-1.22	-2.85
	Bihar				0.10	0.03				-1.61			5.28	-1.17	0.73	3.35
	Delhi	-1.79	0.72							-1.44	-0.16	-0.01				-2.67
	Gujarat								30.72			0.17	2.26	0.67		33.82
	Haryana								1.21		0.84	0.05				2.09
	HP	0.00														0.00
	J&K										-0.02					-0.02
	Karnataka								125.60				0.00	0.92		126.53
	Kerala								1.50				-1.32		0.99	1.17
	Maharashtra	0.05							64.03					0.27		64.35
	Meghalaya	-0.06														-0.06
	Orissa														1.76	1.76
	Punjab							-0.05	0.41	0.22		-0.01				0.57
	Rajasthan							-0.07		0.93			-0.07			0.79
	TN								1.63		-1.01	0.10		2.65		3.38
	Tripura		0.09												-0.08	0.01
	UP										0.32	-1.79			0.30	-1.16
	WB			-0.28	0.31		-1.83	0.26	-0.21	-1.25	6.75	-8.93		-0.19	-0.05	-5.41
	Total	-1.80	0.80	-0.28	0.43	-0.20	-2.39	0.14	218.84	-21.06	6.73	-10.87	6.05	2.96	2.42	201.78

Appendix 45: Inter-state VW-flows embedded in Oilseeds(in GL) (1998-1999)

Oilseeds (1998-1999)		**Exported from**																
		AP	Assam	Bihar	Delhi	Gujarat	Haryana	HP	MP	Maharashtra	Orissa	Punjab	Rajasthan	TN	Tripura	UP	WB	Total
Exported to	AP					-0.10			-2.48	-2.86			-15.98					-21.42
	Assam				-1.39	0.00			-5.03				-0.17	-0.71			-6.73	-14.03
	AR															-6.25		-6.25
	Bihar		0.14			-0.29								11.40		-0.92	1.52	11.85
	Chandigarh	0.41																0.41
	Delhi	-0.93	0.80							-0.27		0.07	-0.33		0.23			-0.42
	Gujarat								37.58			0.01	1.82	3.85		0.85		44.12
	Haryana								13.55			0.35	0.17					14.08
	J&K												-0.02					-0.02
	Karnataka													0.20				0.20
	Kerala	0.02							0.02					-2.90				-2.86
	MP	0.61				-0.10												0.50
	Maharashtra	0.80	0.50			-0.12			6.39							0.14		7.71
	Meghalaya	0.14																0.14
	Orissa				-0.04													-0.04
	Punjab	0.24							0.75	0.85			0.00					1.84
	Rajasthan	0.02								2.17				0.03				2.22
	TN	0.09		-0.29	-1.93		-0.17		0.04	0.38		-0.09	-14.97			6.57		-10.38
	Tripura			-0.04														-0.04
	UP	0.43	0.01									-0.43	-19.67					-19.66
	WB		0.03	-0.25		-0.01		-0.33	-3.24	-3.36	-0.10		-1.21			-0.79		-9.24
	Total	1.82	1.48	-0.57	-3.36	-0.63	-0.17	-0.33	47.60	-3.09	-0.10	-0.09	-50.35	11.88	0.23	-0.39	-5.21	-1.28

Appendix 46: Inter-state VW-flows embedded in Oilseeds (in GL) (1999-2000)

Oilseeds (1999-2000)		**Exported from**															
		AP	Assam	Bihar	Delhi	Gujarat	Haryana	MP	Maharashtra	Orissa	Punjab	Rajasthan	TN	Tripura	UP	WB	Total
Exported to	AP				-1.38		-1.30	-1.69	-4.58			-0.30					-9.25
	Assam				-0.14	-0.99						0.00	-9.13			-2.03	-12.29
	AR											-0.43					-0.43
	Bihar								-3.49	-2.44			17.99			23.10	35.16
	Chandigarh														0.04		0.04
	Delhi	180.17	3.49						-204.07			-0.11		0.41			-20.12
	Gujarat							94.41	5.72			0.44	16.25				116.82
	Haryana	100.66		-0.07	4.79				5.38	1.90							112.66
	HP	-10.05							-76.93								-86.98
	J&K	3.71				-0.33						-0.04					3.33
	Karnataka								19.59								19.59
	Kerala	0.76							-1.84				-3.30		0.00		-4.37
	MP	-5.06				-0.01			-3.69						-0.38		-9.14
	Maharashtra	0.25						3.57							0.35		4.17
	Meghalaya	8.61															8.61
	Orissa	-7.76							-0.31							1.70	-6.37
	Punjab	66.19	0.30	-1.15				3.07	21.25			-0.18					89.49
	Rajasthan	0.83							4.15								4.97
	TN	0.70						1.97	1.80			0.14			3.44		8.05
	Tripura														-0.05	-0.01	-0.06
	UP	8.32							-8.29		0.03	-0.02				0.53	0.57
	WB	-0.84		-0.06		-0.50	0.07	-5.09	-5.96		1.17	-6.07			-1.06		-18.34
	Total	346.47	3.79	-1.28	3.28	-1.83	-1.23	96.24	-251.25	-0.54	1.20	-6.59	21.80	0.41	2.33	23.30	236.10

Appendix 47: Inter-state VW-flows embedded in Oilseeds (in GL) (2000-2001)

Oilseeds (2000-2001)		Exported from																	
		AP	Assam	Bihar	Chandigarh	Delhi	Gujarat	Haryana	MP	Maharashtra	Nagaland	Orissa	Punjab	Rajasthan	TN	Tripura	UP	WB	Total
Exported to	AP								-1.12					-0.01					-1.13
	Assam	-8.18					-0.06		0.58				-0.86	-3.07	-14.69		-0.53	-1.27	-28.08
	Bihar														10.91			4.54	15.45
	Delhi	93.25								-203.76	0.13		0.04	-0.03		0.92			-109.44
	Gujarat								50.04	16.77				0.30	7.22		0.94	0.04	75.30
	Haryana		9.98					0.84		1.35	1.18	-9.21	-2.21		1.75	0.96	0.82	0.06	5.50
	HP	-0.16																	-0.16
	J & K													-0.69					-0.69
	Karnataka	7.68								0.02									7.70
	Kerala								0.03	-2.74					-4.09		-0.01		-6.81
	MP	-34.95								-5.14		-10.17							-50.26
	Maharashtra	0.27		0.31					0.86						0.04		0.37		1.85
	Meghalaya	5.85																	5.85
	Mizoram										-0.05								-0.05
	Nagaland									-1.49				-0.27				0.01	-1.76
	Orissa	-3.66						-1.35											-5.01
	Punjab	7.71					0.10		1.52	3.95				-0.49			0.01	0.52	13.31
	Rajasthan	0.95								3.25									4.20
	TN				0.07	-0.40			1.89	4.95			0.05	1.91			2.23		10.70
	Tripura																-0.40	-0.16	-0.57
	UP	9.81								-1.58				-0.07				0.53	8.70
	WB	-0.22	0.07	-0.01			-0.47	-0.06	-2.76	-12.93			2.19	-4.81					-18.99
	Total	78.35	10.05	0.30	0.07	-0.40	-0.43	-0.58	51.03	-197.35	1.26	-19.38	-0.79	-7.23	1.14	1.88	3.42	4.27	-74.39

Appendix 48: Inter-state VW-flows embedded in Oilseeds (in GL) (2001-2002)

Oilseeds (2001-2002)		**Exported from**														
		AP	Assam	Bihar	Delhi	Gujarat	Haryana	MP	Maharashtra	Orissa	Punjab	Rajasthan	TN	UP	WB	Total
Exported to	AP				-0.02	-0.78		-1.60	-5.90	0.45			2.62			-5.23
	Assam				-0.12	-1.03	-0.02	0.74				-7.89	-3.81	-0.25		-12.37
	AR												-3.02			-3.02
	Bihar					0.24									9.49	9.73
	Delhi	115.34	0.78						0.85							116.97
	Goa	5.92														5.92
	Gujarat							54.01				0.46	13.99	1.85	0.20	70.51
	Haryana	95.37							3.72	0.69						99.78
	Karnataka	1.30		0.35				0.65					0.03			2.33
	Kerala	0.64				0.00		0.40					-3.58	-0.06		-2.60
	MP	66.07				-5.98			-0.12			-0.37		-0.04	24.09	83.64
	Maharashtra	0.38		-0.13				0.31							0.04	0.59
	Meghalaya	4.57														4.57
	Nagaland											0.00				0.00
	Orissa	-4.58		-3.06												-7.64
	Punjab	30.97				0.23		0.28				0.01			27.52	59.01
	Rajasthan	6.15					-0.15		9.60							15.61
	TN	13.42				1.46		1.23				1.73		2.47		20.32
	Tripura														-0.01	-0.01
	UP	14.74	5.20					0.15								20.09
	WB	-4.74	0.02	-0.09		0.42	-4.49	-1.50		-0.08	8.17	-3.10				-5.39
	Total	345.55	6.00	-2.93	-0.14	-5.45	-4.66	54.68	8.15	1.06	8.17	-9.16	6.24	3.97	61.31	472.79

Appendix 49: Inter-state VW-flows embedded in Oilseeds (in GL) (2002-2003)

Oilseeds (2002-2003)		**Exported from**																	
		AP	Assam	Bihar	Delhi	Gujarat	Karnata ka	Kerala	MP	Maharasht ra	Nagalan d	Orissa	Punjab	Rajastha n	TN	Tripura	UP	WB	Total
Exported to	AP			0.09	-0.47				-1.64	-5.53			0.06						-7.49
	Assam				-0.17	0.45			1.33					-5.14	-0.26		-3.18	-14.67	-21.63
	Bihar	-1.12													0.48			112.40	111.76
	Chandigarh														-1.30				-1.30
	Delhi	102.11	1.46						-0.12	-0.19	1.37	0.12				0.15			104.90
	Goa	20.55																	20.55
	Gujarat								19.69						-20.10			0.03	-0.37
	Haryana	30.00								4.36		8.52							42.89
	Karnataka	0.00						0.13											0.13
	Kerala	13.83					-9.92								-0.95		-0.04		2.93
	MP	93.00				-22.01				-0.83					-41.61			9.94	38.49
	Maharashtra	-6.21		-0.14					0.45										-5.90
	Manipur	-3.57																	-3.57
	Meghalaya	2.40																	2.40
	Mizoram	-7.37																	-7.37
	Nagaland	-11.71							0.26					-0.17					-11.62
	Orissa																	0.04	0.04
	P &K	5.66							0.34										6.00
	Punjab	18.55	1.68			-1.49												48.99	67.73
	Rajasthan	5.99		0.31					0.27	2.76									9.33
	TN	31.77	12.43						0.64	-0.08				0.08					44.83
	Tripura		0.11																0.11
	UP	6.45																29.20	35.65
	WB	-14.90		-1.80		0.61			-0.39			-0.28	12.56	-0.94	-1.05		-0.74		-6.93
	Total	285.46	15.68	-1.53	-0.63	-22.44	-9.92	0.13	20.82	0.49	1.37	8.37	12.62	-6.17	-64.78	0.15	-3.96	185.93	421.57

Appendix 50: Inter-state VW-flows embedded in Oilseeds (in GL) (2003-2004)

Oilseeds (2003-2004)		**Exported from**																	
		AP	Assam	Bihar	Chandigarh	Delhi	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	Punjab	Rajasthan	TN	Tripura	UP	WB	Total
Exported to	AP	0.00	0.00				-2.68		1.17	-51.26		0.07			-14.34		-1.37	0.00	-68.42
	Assam	-21.49				-0.13			-24.87		-0.48	-1.37			-7.22		-0.07	-2.92	-58.53
	Bihar		0.22															244.94	245.16
	Delhi	92.73	6.36				-1.85		-105.41	3.30					-1.36	19.09			12.87
	Gujarat	0.44										5.24							5.69
	Haryana								1.57			1.64							3.22
	HP									-8.46									-8.46
	J&K								-0.05										-0.05
	Karnataka														0.01			9.53	9.54
	Kerala	0.01					-4.36								-0.53		-0.05		-4.92
	MP	9.46					-17.49			-46.41			6.19		-11.56			11.69	-48.12
	Maharashtra	0.50			2.24						4.05	-3.46					0.74		4.07
	Manipur									-13.56									-13.56
	Nagaland											-10.26							-10.26
	Orissa	-10.28							-4.29		12.93				-4.48			0.09	-6.03
	Punjab	0.40		0.03											-1.94			41.38	39.87
	Rajasthan		21.94							0.01	6.99	-0.17			-13.78				14.98
	TN						5.65	0.20		2.54	2.15						9.36	18.95	38.85
	Uttaranchal		0.48																0.48
	UP	6.40	3.16				-2.74		5.78	-0.03					-15.44			138.95	136.08
	WB	-6.59		-2.67			-1.95		-3.50	-21.95	0.07		4.38	-0.20			-0.02		-32.42
	Total	71.60	32.16	-2.65	2.24	-0.13	-25.43	0.20	-129.60	-135.82	25.71	-8.29	10.58	-0.20	-70.63	19.09	8.58	462.60	260.01

Appendix 51: Inter-state VW-flows embedded in Oilseeds(in GL) (2004-2005)

Oilseeds (2004-2005)		**Exported from**																			
		AP	Assam	Bihar	Chhattisgarh	Chandigarh	Delhi	Gujarat	Haryana	Jharkhand	Karnataka	MP	Maharashtra	Nagaland	Orissa	Punjab	Rajasthan	TN	UP	WB	Total
Exported to	AP				-196.54							-44.27	-698.40		0.10				-48.46		-987.57
	Assam	-3.79					-2.61	-1.35				-5.52	-6.11	-10.63			-1.52	-9.10	-389.77		-430.39
	Bihar											-94.10	-7.16						-106.80	190.34	-17.72
	Delhi	91.95		0.33								-3.24	-0.02	1.37				-0.02		1.48	91.86
	Goa	2.40																			2.40
	Gujarat											-385.48	-7.16				-43.90				-436.54
	Haryana	6.80						-0.52				-6.56	-20.50		-0.58						-21.36
	Jharkhand														-0.56						-0.56
	Karnataka						-0.03	-0.07					-7.16			7.97					0.70
	Kerala							-0.03				-6.37							-421.54		-427.94
	MP												-15.30					-6.32		5.75	-15.87
	Maharashtra				0.20	-2.20		-0.50				-385.99	-322.11	-10.33	-2.19				-21.22	0.43	-743.91
	Nagaland														-2.72				-150.23		-152.94
	Orissa													-72.01				-45.16	0.00	1.03	-116.13
	P & K																		-305.87		-305.87
	Punjab	9.75										26.69	1.37						1.98	3.04	42.84
	Rajasthan	0.19											2.09	3.66							5.94
	TN								0.50			9.82	22.52	1.89			2.16		242.64		279.53
	Uttaranchal	0.72																			0.72
	UP	0.46	0.27										-2.85	0.16				-0.59		398.03	395.47
	WB	-7.87		-0.17						0.03	-2.26	-67.13	-197.60	0.03	-0.03				-499.35		-774.35
	Total	100.62	0.27	0.16	-196.35	-2.20	-2.65	-2.46	0.50	0.03	-2.26	-962.16	-1258.38	-85.86	-5.98	7.97	-43.25	-61.18	-1698.61	600.09	-3611.69

Appendix 52: Inter-state VW-flows embedded in Food Grains (in GL) (2005-2006)

Food Grains (2005-2006)		**Exported from**																					
		AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Gujarat	Haryana	Jharkhand	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	Punjab	Rajasthan	TN	Uttaranchal	UP	WB	Total
Exported to	AP				0.52	1160.05			-53.87		-7.79		-23.62	-2.80		28.86	159.91			1.89	2.01	2.15	1267.31
	Assam	-80.98		-0.15	-12.94	4.61	-1.84		-354.68				-0.02	-9.32			-1151.64			-67.28	-18.56	-0.12	-1692.93
	AR								-322.71											-4.34			-327.05
	Bihar	-0.15				122.47			2.61		-2.01		-0.63	-2.07			331.99	-1.20			-20.28	4.07	434.80
	Chandigarh	1.59														2.21	0.00			-0.08	-1.48		2.24
	Chhattisgarh	-2.19							130.00				0.06				293.40				3.59		424.86
	Delhi	-14.31				-2.46			-36.04			-1.17	-134.03	-5.49			-57.80		-7.22				-258.51
	Goa								11.87				17.08	-0.28		0.01	44.08	-0.51					72.25
	Gujarat	37.28		0.44		12.49			75.90	1.35			13.49	-0.49			640.74			0.95	1.01		783.16
	Haryana	34.23				2.85					0.12		-0.03	-2.85			0.47	0.44			1.30		36.53
	J & K						1.26		-7.85								-16.28			-84.38	-100.20		-207.46
	Jharkhand			0.16		8.68			95.34					-6.89		10.65	242.71				-49.08		301.56
	Karnataka	3.09			5.46	79.88			83.95				-8.70				1128.49	-10.76		11.11	39.25	2.44	1334.20
	Kerala	187.25			1.73	674.19			345.06				-6.78	6.89			760.64	45.00			27.07		2041.05
	MP					39.14			897.67					-3.65		-5.56	2032.35			0.62	-5.69		2954.87
	Maharashtra	3.51			0.07	251.82			806.36				25.51				2535.21	8.82		-0.10	-0.04		3631.16
	Nagaland	-11.00	61.75			-2.04								-4.35				0.04					44.41
	Orissa	-2.68		-0.15		-114.34			-81.68				-15.99	-59.45			-44.98	-0.78		2.34	5.21		-312.50
	P & K								188.00										-6.22				181.79
	Punjab	-0.80		0.19	0.16				-0.18	0.12			0.79	-0.26						-0.87	-2.08		-2.92
	Rajasthan	2.56							83.80					-1.24		0.03	332.40				-11.56		406.00
	TN	-17.66			1.38	3669.73			48.68		-5.14	-110.89	21.35	1.10	0.52		559.00	310.58	-144.31	33.95	198.78	6.75	4573.83
	Tripura		262.49			2.78											4.80			3.16	5.33	-0.08	278.48
	Uttaranchal			0.64									0.04				6.39				-0.80		6.27
	UP					4.00			-5.72				2.34			-0.05	313.12	-0.18		8.82			322.33
	WB	-19.59	0.28	-1.23		86.31		-0.14	-77.11	-1.71	-97.40		-6.01	-6.98	-3.25	23.61	-864.26	-0.16			-89.48	-1.64	-1058.75
	Total	120.16	324.51	-0.10	-3.62	6000.16	-0.58	-0.14	1829.42	-0.23	-112.23	-112.06	-115.15	-98.13	-2.72	59.75	7250.74	351.31	-157.74	-94.22	-15.71	13.58	15236.99

Appendix 53: Inter-state VW-flows embedded in Food Grains (in GL) (2006-2007)

Food Grains (2006-2007)		**Exported from**																				
		AP	Assa m	Bihar	Chand igarh	Chhatt isgarh	Delhi	Goa	Harya na	Karna taka	Kerala	MP	Mahar ashtra	Nagal and	Orissa	Punja b	Rajast han	TN	Uttara nchal	UP	WB	Total
Exported to	AP			5.25		184.23	90.03		6.27	-1.95		-256.29	-1.82		47.62	66.52	0.12	-4.84		4.00		139.13
	Assam	-88.15			-4.21	2.37	192.19		-239.70			-4.61	-22.17	-2.38	2.29	-435.31		-28.74	-30.29	-46.44	4.18	-700.97
	AR								-323.20													-323.20
	Bihar	-14.78				75.46	1.32		7.76			-45.88	-5.05		11.75	103.80		-64.18	3.57	-2.47	-0.01	71.31
	Chhattisgarh	18.78							36.33			-2.93				48.32		-9.76		15.36		106.10
	Delhi	-42.64		-3.43					-78.48			48.05	25.66			-113.78		22.33		-2.20		-144.49
	Goa						22.88		0.92	3.95					0.96	50.88				1.24		80.82
	Gujarat	63.51				11.74	78.63		24.42	1.68		8.14	2.52		10.19	127.48			0.06	11.06		339.43
	Haryana	29.97				5.81	5.72			0.01		1.60			1.31	7.15			-0.04	1.26		52.79
	J & K															-41.49			-5.58			-47.08
	Jharkhand	-8.22		-14.65		8.06			32.01						27.75	172.02		-34.64		-73.35		108.97
	Karnataka	6.63		6.62	1.37	182.80	89.15	-15.77	48.41			-56.18	0.65			530.80		-482.55		50.15		362.07
	Kerala	229.71		1.75		53.31	90.62	-5.81	69.94			3.73	2.24			153.45		0.66		6.27		605.88
	MP	14.21				35.29	7.26		486.31				0.87		0.96	261.80		-2.46		-8.28		795.96
	Maharashtra	45.21		7.79		87.33	92.47		287.64	2.09		-19.15			2.99	552.91		-1.89		13.61		1070.99
	Nagaland	6.88	-24.44			-2.09			-36.49						100.37	-5.42	-0.20				-17.90	20.71
	Orissa	-16.15	-0.81			-4.52	6.44		-46.38			-31.09	-40.86	-0.30		39.36	-1.74	-93.01		4.50		-184.57
	P & K						42.15					5.71						-1.57				46.29
	Punjab	13.10					-0.04		-0.51	-1.18		10.24							-0.55	-3.22		17.84
	Rajasthan	1.28							45.17			0.21	-6.41		32.97	62.08		1.69		-3.57		133.43
	TN	-18.43		18.86		310.68	3117.80		110.10	32.15	-93.98	106.95	-2.31	0.52	18.26	120.45	0.62			83.93		3805.60
	Tripura	1.38	258.10			13.90	9.97		2.81							11.52				0.85		298.53
	Uttaranchal								-0.28							16.29				-0.31		15.69
	UP	4.35				2.32			-3.87			4.63	43.92		-0.17	429.00		-0.94			-0.34	478.88
	WB	-258.16				41.92	17.73		-45.36	-29.52		-19.50	-5.37	-0.73	9.56	144.55		-323.77		-21.30		-489.96
	Total	-11.54	232.85	22.19	-2.84	1008.61	3864.33	-21.58	383.83	7.23	-93.98	-246.37	-8.12	-2.89	266.80	2302.38	-1.20	-1023.68	-32.84	31.08	-14.07	6660.18

Appendix 54: Inter-state VW-flows embedded in Food Grains (in GL) (2007-2008)

Food Grains (2007-2008)	Exported from																						
Exported to	AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Goa	Gujarat	Haryana	J & K	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	P & K	Punjab	Rajasthan	TN	Uttaranchal	UP	WB	Total
AP				0	81	-1			-3		-422		-322	-12		45		41	-1			2		-591
Assam	-109			0	7	47			-140		-27		-56	-88	1	6	-3	-936				-33	-22	-1353
AR									-1									-7						-9
Bihar	-31				254				9		-4		-1	-7		25		198			2	-21	5	428
Chhattisgarh	0				0				17				0			1		51						69
Delhi	-8				-3				-92		-15		-42	13		-1		-134		31				-251
Goa					0				15				4			0		25						44
Gujarat	56				5	16			28		40		164	2		6		206	0			4		529
Haryana	22				3	11					0		8	1		-1		0	-2			6		47
J & K									-4									-82	-1			0		-87
Jharkhand	-94				14				39					-9		37		100	0			-5		82
Karnataka	18			1		-46	0		26				-174	-26		0		723	-5	-24		50		543
Kerala	-3105				-196	9			30		-3	-36	75	-32		-4		-47	220	0	-7	-33		-3129
MP	4				2				306									84	3			-1		398
Maharashtra	20				80	27			396	7	-9		42		0	30		1008	6	2	-1	2		1609
Mizoram																						0		0
Nagaland		-2			-2	1			-19					-3		109		-95				0	-13	-23
Orissa	-5		1		-5	3			-9				-149					18	0			12		-136
P & K	3					11							6							0				20
Punjab	0		0		2	45					-2		-3	0								-1	0	41
Rajasthan	4								42						0	4		42						92
TN	-12				484	-52		0	4		-462	-20	206	-1	2	9		183	541			41		923
Tripura	2	134			6	6			0									21	1			4	0	174
Uttaranchal											-1		0					6						5
UP	-23			1	4				-13					60	-3	-2		282		-1			-4	301
WB	-374		-1		167	22			-40		-59		-31	-43	-6	44	-1	173	-2	-4		-75		-230
Total	-3632	132	0	3	902	100	0	0	588	7	-965	-56	-273	-144	-7	308	-4	1860	761	3	-6	-47	-34	-504

Appendix 55: Inter-state VW-flows embedded in Food Grains (in GL) (2008-2009)

Food Grains (2008-2009)		Exported from																						
		AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Haryana	J & K	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	P & K	Punjab	Rajasthan	TN	Tripura	Uttaranchal	UP	WB	Total
Exported to	AP					286.11		15.89		-8.63		-191.55	-12.47		25.44		308.12	-2.62			0.21	22.42	11.85	454.77
	Assam	-89.21			-12.10	2.31	27.92	-323.83				-4.81	-30.47	-3.02			-1036.06	-0.80	-5.31	-0.10		19.01	-8.02	-1464.48
	Bihar	-0.34				301.11		6.88		-0.43		-0.83	-4.33		31.54		80.47					-9.76	7.02	411.34
	Chandigarh						2.30					0.42					0.00							2.71
	Chhattisgarh							13.01				-1.00					30.70						-0.60	42.12
	Delhi	-15.67				-2.57		-37.43				-27.87	42.07				-81.96							-123.42
	Goa					6.11		1.53									58.44							66.07
	Gujarat	44.73				24.38	7.23	60.35		5.44		314.73	0.99		2.05		376.74	-0.28				3.96	18.65	858.95
	Haryana			0.09		3.09				0.00		7.32	0.52				0.60					3.37	2.91	17.91
	J & K			-0.04				-21.79									-90.05							-111.88
	Jharkhand					20.78		70.15					-26.49		29.06		123.59					46.36	-0.85	262.60
	Karnataka	206.67	0.11		2.96	0.06	4.65	31.30			-4.59	-135.28	0.41	-0.23	3.62	2.43	1037.02	-7.73	-5.94			93.77	8.57	1237.83
	Kerala	-3386.35				-218.68		69.27		15.19	-18.87	34.22	-25.61				493.29	88.19				34.62	-15.31	-2930.03
	MP			-0.40		12.74		10.14					2.70				1.70					3.00		29.88
	Maharashtra	18.98		2.32	0.75	54.66	33.35	1070.38		-3.92		42.04			0.64		3570.67					334.62	3.55	5128.06
	Nagaland	-2.87	-0.40		-7.66	-0.67	-0.64	-50.33							-0.39		-42.54		-3.71			11.38		-97.83
	Orissa			-1.13		-1.63	2.96	10.70				-19.16		-0.30			47.44	-1.17				18.95		56.64
	P & K	-1.77				1.80																		0.03
	Punjab	0.12				4.19	41.42		0.01	-2.17		-14.08	-1.01								-1.30	-3.65	1.33	24.85
	Rajasthan	3.27						32.00							1.00		56.05							92.32

		AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Haryana	J & K	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	P & K	Punjab	Rajasthan	TN	Tripura	Uttaranchal	UP	WB	Total
	TN	-41.96				226.29	14.90	94.03		-271.32	-28.58	147.24	12.91	1.91	48.13	0.41	1398.18	398.61				143.97	0.42	2145.14
	Tripura		233.25			29.10											4.57					5.88		272.81
	Uttaranchal							-1.20		-4.31		5.73					-108.92					-0.89		-109.58
	UP	14.69						-8.30				-35.16	-14.70	-2.30	-0.90		14.50		-2.97				-3.16	-38.31
	WB	-5.31		-1.12		5.38	7.42	-64.14		-10.17		-25.05		-3.41	20.60		225.79					-6.14		143.84
	Total	-3255.01	232.97	-0.28	-16.04	754.53	141.51	978.61	0.01	-280.32	-52.03	96.89	-55.47	-7.37	160.80	2.84	6468.34	474.20	-17.93	-0.10	-1.09	720.89	26.37	6372.31

Appendix 56: Inter-state VW-flows embedded in Food Grains (in GL) (2009-2010)

Food Grains (2009-2010)		Exported from																				
		AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Haryana	J & K	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	Punjab	Rajasthan	TN	Uttaranchal	UP	WB	Total
	AP			-1.30		0.49	-4.99	5.58		-27.85		-59.12	-25.57		5.89	117.81	-0.29			34.39	1.29	46.32
	Assam	-94.22			-6.89	1.26	13.15	-77.24					-22.06	-7.76		-748.59			-128.82	4.96	-20.21	-1086.41
	Bihar	0.01				266.60		5.48		-9.26		-7.47			38.96	179.34				-14.45	127.58	586.79
	Chandigarh						5.44	-24.36								-11.46			-7.48	-3.01		-40.87
	Chhattisgarh	-0.47						167.64								129.69						296.86
	Delhi	-16.13				24.12		-129.00		9.97		-42.08	-48.01			-102.25		95.58		-14.24		-222.03
	Goa					27.50		8.51					3.28			43.57						82.86
	Gujarat			3.61		98.00	14.29	51.03		46.46		138.38				471.72	0.97			29.01	9.20	862.66
	Haryana	20.51				9.44	0.01	1.67		0.13		19.17				0.07			0.60	0.01		51.61
	HP			9.19				-0.94								5.67			-1.08			12.83
	J & K				-0.49			-2.90					-5.15			-61.78			-3.96	-23.60		-97.88
	Jharkhand					4.80		90.79					-2.34		66.64	209.50		0.20		4.88	-12.98	361.50
Exported to	Karnataka	161.80			8.69		-2.28	19.32				-65.65	-6.85			793.88	-0.93			169.99		1077.98
	Kerala	167.25				194.44		116.02		10.17		45.63	17.71		32.58	436.65	70.33			226.25		1317.04
	MP	2.55				14.11		298.57					-6.41			1117.20			-9.18	13.69		1430.53
	Maharashtra	4.92				759.97	25.90	679.14		-11.91		42.36			1.08	2902.30	0.00	25.33		359.82		4788.91
	Nagaland	-0.85	4.70			-0.71	-0.65	-34.52								-73.04			-16.20	10.56	-6.14	-116.86
	Orissa	-1.95			1.37	-6.66		19.84								88.03				7.06		107.69
	P & K	-4.10				1.90									4.76			-0.42		13.07		15.21
	Punjab	-1.93				22.39	-0.11		0.18	-67.83		26.01					0.68	0.11		-58.98		-79.49
	Rajasthan					0.41	0.01	138.41				-11.03	-3.43	3.19	8.43	180.67						316.66
	TN	-26.77				359.86	-69.84	60.00		-241.45	-20.30	138.64	30.94	11.15	389.15	942.79	243.64		-12.23	453.01	10.77	2269.35
	Tripura		191.92													0.83				18.20	22.41	233.36
	Uttaranchal					3.45				-36.13		1.28				22.07						-9.33
	UP	47.56				4.30		-1.09		-0.07		14.87	-42.62	-7.55	-1.76	54.20		-0.62			7.22	74.43
	WB	-13.63	-0.01	-6.58		7.02	-2.04	-51.07		-150.74		-13.37	2.43	-27.05	19.65	307.33	-0.02	-8.24		-0.40		63.28
	Total	244.55	196.61	4.92	2.68	1792.71	-21.12	1340.88	0.18	-478.51	-20.30	227.63	-108.08	-28.00	565.37	7006.20	314.37	111.94	-178.36	1230.21	139.13	12343.01

Appendix 57: Inter-state VW-flows embedded in Food Grains (in GL) (2010-2011)

Food Grains (2010-2011)	**Exported from**																						
Exported to	AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Goa	Haryana	J & K	Jharkhand	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	Punjab	Rajasthan	TN	Uttaranchal	UP	WB	Total
AP					5.05			1.40			-539.54		-37.72			37.74	4.65	-7.06			8.24	1.68	-525.56
Assam	-74.68			-3.44	1.60	2.75		0.37						-24.17	2.20		-403.73			-235.80	-65.97	-10.64	-811.51
AR																					-0.89		-0.89
Bihar	-13.82				133.19			1.60		-2.03	-17.19		-3.30			43.95	61.95	-0.95		1.43	-6.99	23.39	221.23
Chandigarh						2.58		-3.65						-4.55			-7.16			-6.02			-18.80
Chhattisgarh								16.57						0.78			19.59						36.95
Delhi	0.64		-3.69		1.39						2.55		-1.66	-23.51			-7.07		23.50				-7.84
Goa					16.87								8.81				3.79						29.47
Gujarat			7.86					3.26			27.04		15.04				161.81			0.56	73.95	4.76	294.28
Haryana	7.65				3.11						0.07		8.62				0.95	4.93					25.33
HP			9.31					-0.31			-0.27		8.30			20.91	8.98					2.74	49.66
J & K				-0.49													-28.66				-12.92		-42.07
Jharkhand	-2.22				31.44			18.80						-9.79		46.31	87.43					-0.41	171.56
Karnataka	33.99			2.89				7.40					-53.61	-1.82			334.35	-4.56			117.51	1.04	437.18
Kerala	119.43				8.40		-17.12	-1.15			-15.97		-177.54	-8.91			-74.31	-206.87	0.23		-61.39		-435.18
MP	1.28				58.48						2.70						369.11						431.56
Maharashtra	0.50		2.88		658.15		-3.44	143.19			-11.93		3.95			0.36	1099.84	9.96			56.75	2.31	1962.53
Manipur		9.64																					9.64
Nagaland		6.78			-1.43	-0.07								-4.64			-63.34			-10.01	-9.91	-2.02	-84.64
Orissa								4.40						0.00	-6.37		45.66				5.78		49.47
P & K	-2.85																		-0.42				-3.26
Punjab			-0.72						0.18		-7.51		-9.82								-4.19		-22.07
Rajasthan	2.34												-3.67	-8.56	-4.05	2.58	23.89						12.51
TN	-34.74		-0.78		15.69			-1.67			-331.97	273.02	165.80	15.67	2.75	23.97	411.62	412.16			411.93		1363.47
Tripura		263.43																			5.80	6.45	275.68
Uttaranchal					12.62						-12.79		2.29				8.71						10.82
UP	8.05				2.38			-2.24			-2.09		-7.21	-168.76		-4.29	62.33	-17.15				3.92	-125.06
WB	-124.87		-3.06		31.69			-15.28			-156.60		-40.62	-2.95	-15.61	61.40	147.75	7.41	0.43		-0.09		-110.38
Total	-79.31	279.85	11.81	-1.04	978.63	5.27	-20.56	172.71	0.18	-2.03	-1063.49	273.02	-122.34	-241.21	-21.09	232.94	2268.11	197.89	23.75	-249.84	517.62	33.23	3194.08

Appendix 58: Inter-state VW-flows embedded in Food Grains (in GL) (2011-2012)

Food Grains (2011-2012) — Exported to	Exported from: AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Gujarat	Haryana	J & K	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	P & K	Punjab	Rajasthan	TN	Tripura	Uttaranchal	UP	WB	Total
AP	2600107.25		-3.51		1208665.99	-11.23		6.99		-242.51		29555.78	1132323.45		43415.73		17920.78	-17.26			21054.08	190095.70	4.57	5242875.81
Assam			-1.05	34438.01	24725.73	338520.03		357328.41				0.00	45415.74				4515473.71	1606.40		684.34	610943.11	38275.13	40715.67	6008125.23
Bihar	329445.74			31645.30	2709807.38			450259.67				-2.37	-2.79				1348600.99				4.87	18053.60	0.47	4887812.87
Chandigarh						452807.89		1136618.96				0.04	103630.60				4557605.67					25156.62		6275819.79
Chhattisgarh								167.83				8.67	0.00				117.17				14004.70	63575.34		77873.71
Delhi	3.02							115252.45		-1.31		27629.99	238825.30				177519.38	-12.44				-7.14		559209.24
Goa					18617.73			249796.01				22711.62	4.97		3.75		248993.50							540127.57
Gujarat	266739.45		3.98		447842.30	139876.45		461117.89		28.91		-314.93	173563.20		141960.74		1869597.05	0.78			312111.29	565261.86		4377788.97
Haryana			4.32		13315.37	0.01				0.03		7.33	8.24				1384.22					3.77		14723.28
HP			6.29		38833.76	30498.17		199469.31					0.87				117809.27							386617.68
J & K	7501.42			14252.83	15237.14			17227.88									1509727.86	-16.69				-26.85		1563903.61
Jharkhand	75681.83				3740781.29			27836.87					25480.61		195927.64		12208.71					4.88		4077921.83
Karnataka	7138366.30			57768.34	79699.19	-15.35		2143553.45				-78.71	21210.73	-2.41			8981512.38	-18.95				2166.02		18424160.98
Kerala	10206361.39		0.52					473136.52		-6.51	239079.98	28.99	1.88		56285.79		1578679.91	274.57				116421.39	2.72	12670267.15
MP					196738.21			222450.73		-1.28							313618.36	3.71				2.79		732812.52
Maharashtra	245116.81				787696.16	29.35		2607206.76		-20.87		306642.85	60088.47		28643.84		5864169.37	25.32			43483.59	59169.82	2.14	10002253.60
Manipur		350857.37			9521.92																			360379.29
Nagaland		7014.00				3970.23		112897.08					9112.22				373181.60					3.92	12043.37	518222.42

	AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Gujarat	Haryana	J & K	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	P & K	Punjab	Rajasthan	TN	Tripura	Uttaranchal	UP	WB	Total
Orissa					56631.58			59894.96				-14.23		-255.72			42097.77					1875.59		160229.95
P & K	23377.34																							23377.34
Punjab	35233.60		-1.45			-0.02			0.18	-14.53		-22.32	-7.19					-2.62				18425.70	0.51	53611.86
Rajasthan								3275.95						-240.49	1.09		1592.69					3.19		4632.43
TN	18297844.84		15.48		540040.44	-114.49		505891.69		-521.74	1423577.51	252707.89	43938.85	11.96	115.30	22851.53	1405168.61	1444.06	404633.55		7.18	470.74	6.73	22898090.12
Tripura		1404285.43															18815.57					2.91	2.97	1423106.88
Uttaranchal					16.11							0.75	-9.50				310778.61							310785.97
UP	37578.13							1498536.91		-0.68		-3.35	1991784.68	-3.82	-13.39		1807914.33		-3.00				0.63	5335790.44
WB	602994.22		-4.41		1321333.93	98.57	-3.04	234286.13		-42.32		11855.49	127389.56	-47.52	-4.72		226754.49	7.06				29084.85	25419.64	2579121.94
Total	39866351.35	1762156.80	20.16	138104.48	11209504.24	965659.61	-3.04	10876212.44	0.18	-822.82	1662657.49	650713.50	3972759.89	-538.00	466335.77	22851.53	35301242.01	3293.95	404630.55	684.34	1001608.82	1128019.84	78199.41	109509642.49

Appendix 59: Inter-state VW-flows embedded in Food Grains (in GL) (2012-2013)

Food Grains (2012-2013)		Exported from																							
		AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Goa	Gujarat	Haryana	J & K	Jharkhand	Karnataka	Kerala	MP	Maharashtra	Orissa	P & K	Punjab	Rajasthan	TN	Uttaranchal	UP	WB	Total
Exported to	AP	11347.61		-38.43	6884.50	677.67	-8.77			422820.87		14.99	-195.85		4675531.96	18546.58	9748.08		603973.26	129483.08	138807.24		16798.22	28.13	6034419.16
	Assam	-2.27		7538.00	-3.44	0.66	2255.58		-6.24	59121.24			-3.30			-7.49			154467.08	-0.35		-139.39	6916.34	-1.59	230134.83
	Bihar	-8.50				268.46				467742.90			-6.39		144757.63	0.02	60.57		844458.69			28960.28	13536.54	1151.12	1500921.32
	Chandigarh					1.83	172.31			98245.72						-62.48			721375.25			-11.95	20280.96		840001.65
	Chhattisgarh									238323.61					2559937.38	0.49			68478.48			-3.16	-2.56		2866734.23
	Delhi				-6.35	-5.37			4.27	69219.35			0.03		5792.59	-73.20			76678.16	17688.57			7295.26		176593.32
	Goa					34.77				70173.05			1.30		716945.48	177838.85			239536.27						1204529.71
	Gujarat	1.26		26.92		26.19	14.93		391542.92	3347957.03					4334722.14	106.20			3420259.69	280582.60		1.22	1804542.55	18.51	13579802.14
	Haryana			6.52			0.01								15.13	4.46							2234.00		2260.12
	HP			11.16						85519.30									839559.00				6066.16	5.51	931161.13
	J & K				-0.99	1.99				15003.49						-5.06	3.77		343423.82	6490.79			54224.20		419142.02
	Jharkhand	-32.90				24.33				144230.12						-2.40	111.33		125601.22					-2.70	269929.00
	Karnataka	162.30		6.47	2.89	16.10	-28.06		12438.44	682805.97				21218.20	1682945.03	17978.03			1289151.01	493968.76	220231.70		421098.29		4841995.13
	Kerala	192.02		0.53		7.58				1019219.08			-8.52	170849.18	1899576.68	36271.97			1398938.86	1552698.60	43201.90		104787.02	-3.29	6225731.61
	MP			0.83		0.26				611089.78						-23.71			660462.68					28350.00	1299879.85
	Maharashtra	0.99		13.84	0.76	511.42	16.82	89643.67		4413131.49			-10.96		20403067.05	293662.42			2279591.62	232361.96			28772.59	6.51	27740770.17
	Manipur		45072.28																						45072.28
	Mizoram			2.76		4.01																			6.77
	Nagaland		-7.45			-1.49	-0.70			11894.10									18685.36					-2.93	30566.89

	AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Goa	Gujarat	Haryana	J & K	Jharkhand	Karnataka	Kerala	MP	Maharashtra	Orissa	P & K	Punjab	Rajasthan	TN	Uttaranchal	UP	WB	Total
Orissa					-0.06				754010.11					361289.02				677075.90	-0.97			4706.16		1797080.16
P & K	-5.14															2.44				21162.18				21159.47
Punjab	-0.41		-1.44		4.30				-0.02	3690.73				22394.08	-3.62				6841.52			289733.61	0.51	322659.27
Rajasthan									2215277.46									403557.83				4386.05		2623221.34
TN	-37.97		-16.14		9704.06	-66.06		22017.84	1243181.53			49525.10	1191198.80	8691427.35	1.21	53.65	3.48	2289922.40	3365369.53	1602162.65	-4.09	626074.68	0.31	19090518.34
Tripura		60566.54																				5338.53		65905.07
Uttaranchal									63826.85					1.63	-2.77			128813.88						192639.59
UP				1.56				13.89	208507.64					43174.35	-74.37			121354.26					-0.37	372976.96
WB	-1.53	0.04	-4.66		2.78	-2.87			2401161.66		9803.62	-15.02		198010.78	-34.31	6.88		2176041.44	8643.98			239961.13	127640.16	5161214.09
Total	11615.46	105631.41	7546.38	6878.94	11279.49	2353.18	89643.67	426011.12	18642462.31	3690.73	9818.61	49286.40	1383266.18	45739588.27	544120.83	9986.74	3.48	18881406.16	6094128.07	2025565.66	28802.91	3656749.71	157189.89	97887025.63

Appendix 60: Inter-state VW-flows embedded in Food Grains (in GL) (2013-2014)

Food grains (2013-2014)	**Exported from**																							
Exported to	AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Gujarat	Haryana	HP	J & K	Jharkhand	Karnataka	Kerala	MP	Maharashtra	Orissa	P & K	Punjab	Rajasthan	TN	Uttaranchal	UP	WB	Total
AP			-23.45		871.80	-11.06		142.27		-0.89	4.25	-309.07		-998.48	-8.71	71.17		241.49	-1.81		-3.95	8.62	19.55	1.72
Assam	-2.93			-1.74	4.06	-5.49		-679.63						-2.54	-32.58	6.29		-912.72	0.00		-107.24	-7.97	0.11	-1742.40
Bihar	-7.86				479.97			-21.17		0.69		-4.15		-53.80	-7.78	286.01		591.04			-9.55		20.15	1273.55
Chandigarh					1.84	0.36						-0.85			-8.50			-0.43			-3.02	-0.76		-11.36
Chhattisgarh								172.25						16.48	-1.90			175.18			-3.16			358.86
Delhi								-337.84							-24.19			-168.42	-20.47	126.33		-7.92		-432.52
Goa					23.02			86.19						61.06	20.74			141.77				28.56		361.34
Gujarat			65.34	2.19	31.84			708.92						-181.23	21.00			1741.49	-0.52			245.20	32.10	2666.34
Haryana	2.66		4.33							6.97		0.15		-6.75	30.53				-1.64			3.24	12.06	51.55
HP					10.03											17.55		1.63						29.21
J & K					7.79			-62.16										-87.93						-142.30
Jharkhand	-30.62				28.36										-2.40	120.25		-4.04					-1.08	110.47
Karnataka	26.77		15.12	1.98	186.34	-29.50	-0.04	138.56						-670.59	0.66	30.12		965.85	-14.35	5.49		161.13	5.63	823.17
Kerala	129.65				27.40			385.13				-4.83		36.46	3.73			635.90	293.47	0.05		141.64		1648.61
MP	1.26							18.87							-2.03			-1.04	10.99					28.05
Maharashtra	1.18		12.58		633.36	0.04	-0.54	847.18				-8.28		-226.73				1757.42				47.31	6.75	3070.26
Manipur		24.83																						24.83
Nagaland		-1.42			-4.50	-4.88		-31.41							-13.90			-68.50				-6.73	-1.81	-133.15
Orissa					-1.18			36.12						-626.11				108.95				1.85		-480.36
P & K	-2.10																							-2.10
Punjab			-2.52		-0.16	-0.02		-13.16				-9.53		2.87	-102.73							-3.21	0.51	-127.94

	AP	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Gujarat	Haryana	HP	J & K	Jharkhand	Karnataka	Kerala	MP	Maharashtra	Orissa	P & K	Punjab	Rajasthan	TN	Uttaranchal	UP	WB	Total
Rajasthan								378.05						-32.57				209.11				13.59		568.18
TN	-33.71		-20.59	7.88	272.48	-66.57		1153.86		-0.63		-248.74	-39.73	534.41	-6.58	90.93	0.97	861.62	739.80			462.80	9.95	3718.16
Tripura		233.38																3.83				2.92	3.00	243.13
Uttaranchal			4.42					-17.90				-1.22		0.46	-32.66			21.66					3.46	-21.79
UP				1.56	3.53		-3.55	-99.91						-190.89	-45.97			1098.36					-0.38	762.77
WB	-0.83		-5.60		29.80	-3.56	-4.19	-56.80	0.03			-114.85		-10.54	-34.78	69.02		496.08				-6.49		357.28
Total	83.46	256.79	49.64	11.87	2605.78	-120.70	-8.32	2747.43	0.03	6.13	4.25	-701.37	-39.73	-2348.49	-248.04	691.34	0.97	7808.32	1005.48	131.87	-126.92	1083.79	109.99	13003.56

Appendix 61: Inter-state VW-flows embedded in Oilseeds (in GL) (2005-2006)

Oilseeds (2005-2006)		**Exported from**																
		AP	Assam	Chhattisgarh	Chandigarh	Delhi	Haryana	Jharkhand	Karnataka	MP	Maharashtra	Nagaland	Orissa	Punjab	Rajasthan	UP	WB	Total
Exported to	AP			4.17					-2.43	-105.72	-143.52		-0.05			-0.95		-248.50
	Assam	-5.75		-0.02		47.54				-998.09		-0.67	12.93		-11.61	-6.94	-0.11	-962.71
	Bihar			0.96						8.46			0.22		7.57	4.27	2071.25	2092.72
	Chhattisgarh	-9.65								-0.47			13.83					3.71
	Delhi	-92.41						2.06		5.70	-0.20		49.77					-35.07
	Goa											16.03	125.89					141.92
	Gujarat			5.01						490.91	3.03	0.07	32.32		31.48	1.14		563.95
	Haryana									6.16	2.93	11.75	17.00		-2.59			35.23
	HP		0.92															0.92
	Jharkhand										-1.17							-1.17
	Karnataka										0.49		34.73					35.22
	Kerala	-3.67		2.17						-23.73			0.85			-0.77		-25.14
	MP	-23.63		0.08					-5.78		-15.73						47.80	2.74
	Maharashtra			0.42						1165.08		13.08	149.02			16.90		1344.50
	Manipur												-5.67					-5.67
	Nagaland		1.46							-55.42			18.81		0.06	0.57		-34.52
	Orissa	-51.98										-90.28			-0.65		70.36	-72.56
	Punjab	8.68					-0.67	35.59		218.52	-0.46				-2.05	13.60	5.24	278.45
	Rajasthan			0.09							-7.18	-0.45	3.83		0.00			-3.72
	TN	-2.90				0.05				113.77	-27.20	0.02	0.77	-0.39	2.85	3.92		90.89
	UP	0.00		0.25	-0.04			3.11		21.58					-94.90		1381.35	1311.35
	WB	0.09	1.61	-0.01		0.05		0.81		-173.24	-23.11		21.24		-141.40	-6.96		-320.92
	Total	-181.20	3.99	13.11	-0.04	47.64	-0.67	41.57	-8.21	673.52	-212.13	-50.46	475.50	-0.39	-211.25	24.77	3575.90	4191.63

Appendix 62: Inter-state VW-flows embedded in Oilseeds (in GL) (2006-2007)

Oilseeds (2006-2007)		**Exported from**																	
		AP	Assam	Chhattisgarh	Delhi	Gujarat	Haryana	Jharkhand	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	Rajasthan	TN	UP	WB	Total
Exported to	AP			3.89							-10.11	-106.04		-11.65			-0.94	-0.03	-124.89
	Assam	-3.81			21.89		-0.05				-8.02		-6.26	-34.38	-3.57		-0.16	-8.36	-42.73
	AR										-0.18						-6.22		-6.40
	Bihar										24.56	-2.70		2.67	3.87		1.13	768.01	797.54
	Chhattisgarh	-16.63												-21.12					-37.74
	Delhi	-157.16									-3.89	-17.22	0.66	23.87	-3.22	-0.94			-157.90
	Goa												-0.59	12.87					12.28
	Gujarat			7.45			-0.09				191.43	1.23	0.65	3.14	51.60		2.80		258.21
	Haryana	6.93									0.06	0.03		23.65			2.08		32.76
	HP		0.87																0.87
	J & K										3.44								3.44
	Jharkhand			2.78							0.46								3.24
	Karnataka		0.03	5.04							23.94			-1.56	8.57		1.70		37.72
	Kerala			0.11					-59.41		-0.38	-3.01			-0.05		-0.86		-63.60
	MP	-10.30										-2.33			-23.07			-1.34	-37.05
	Maharashtra	1.90		5.97		-0.16					342.31		-1.29	13.46	4.23		0.72		367.14
	Nagaland		0.38								12.91			1.62	0.45		1.62		16.97
	Orissa	-54.80											-49.35		0.14			21.84	-82.17
	Punjab	1.78		2.02					-9.43		69.37	-1.40		0.06	-12.41		2.34		52.33
	Rajasthan								-22.94			-3.26	-0.98	-9.23			0.05	-0.18	-36.54
	TN	0.25		3.90					-3.99	3.69	57.99	-13.23		7.88	6.81				63.30
	UP								-12.47		0.65	-1.13			-23.12	15.55		713.54	693.01
	WB	-0.52	3.92	-0.10	0.23		-19.88	0.27			-95.09	-78.27	-0.16	-12.74	-136.51		-21.09		-359.93
	Total	-232.34	5.19	31.05	22.11	-0.16	-20.02	0.27	-108.24	3.69	609.46	-227.33	-57.31	-1.46	-126.29	14.61	-16.84	1493.47	1389.87

Appendix 63: Inter-state VW-flows embedded in Oilseeds (in GL) (2007-2008)

Oilseeds (2007-2008)		**Exported from**																	
		AP	Assam	Chhattisgarh	Delhi	Gujarat	Haryana	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	Punjab	Rajasthan	TN	UP	WB	Total
Exported to	AP			2.62						-68.22	-88.54		-3.78						-157.93
	Assam			-0.08	43.53			-16.17		-43.94		-7.08	-31.02		-7.39	-306.22	-3.70	-46.66	-418.73
	AR									-1.85									-1.85
	Bihar		0.24	2.23						37.60	-0.27				4.19			593.36	637.36
	Chhattisgarh	-3.44																	-3.44
	Delhi	-46.89	24.69					19.31		-68.71	-16.42	2.66	25.50		-11.58			1.18	-70.26
	Goa											-0.12	7.84						7.72
	Gujarat									409.93	0.01	0.58	-16.81	0.53	130.84				525.09
	Haryana							37.15		7.10			21.19		-0.58	6.09			70.95
	J & K									7.52							-4.99		2.53
	Jharkhand												11.30						11.30
	Karnataka									46.29			-1.01		57.20				102.48
	Kerala			9.75				-51.84		-0.99	-2.46				-0.10	-2.42	-0.39		-48.45
	MP			18.28				-52.05					5.71			-8.01			-36.07
	Maharashtra			1.80						308.84		-3.53	4.72		12.64				324.48
	Nagaland		4.00		0.21					4.17			9.72		0.31		2.01		20.42
	Orissa	-30.02		-0.02		-0.26						-57.93			0.14			7.39	-80.69
	Punjab							-31.48		67.42					1.80	-0.40			37.34
	Rajasthan	-14.67					0.52	-79.19				-1.81	-3.54						-98.70
	TN	1.36		65.70				-1.81	9.27	78.24	-9.14	4.44			6.63		0.41		155.11
	Tripura		0.12																0.12
	UP	2.89					3.08	-2.70		0.27	18.53		1.62	-0.90		-18.64		539.50	543.63
	WB	-0.99	12.85	-0.40	0.26		-4.50	-12.64		-164.28	-83.77	-0.72	-0.29		-22.91		-1.23		-278.61
	Total	-91.76	41.89	99.88	44.00	-0.26	-0.90	-191.43	9.27	619.40	-182.05	-63.49	31.13	-0.37	171.20	-329.60	-7.90	1094.78	1243.79

Appendix 64: Inter-state VW-flows embedded in Oilseeds (in GL) (2008-2009)

Oilseeds (2008-2009)	**Exported from**																
Exported to	AP	Assam	Chhattisgarh	Delhi	Haryana	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	Punjab	Rajasthan	TN	UP	WB	Total
AP			0.76			-3.68		-47.76	-17.86		-1.20			0.00			-69.74
Assam	-5.21		-0.53	105.95	0.00			-57.90		-2.39	-3.10		-0.89	-268.41		-29.85	-262.33
AR								-1.98									-1.98
Bihar				0.03		77.97		17.83					1.82	-54.05		1445.39	1488.99
Chhattisgarh	-2.93																-2.93
Delhi	-64.84							-6.74			0.30						-71.28
Goa											-2.10						-2.10
Gujarat		0.00		0.00	0.00			450.13		-1.32	-53.35	0.00	34.52		16.37		446.34
Haryana											1.89						1.89
J & K								16.98									16.98
Karnataka								47.64			1.71		2.06				51.41
Kerala			8.98					-0.47							-0.49		8.02
MP						-54.00								-8.01		-3.58	-65.59
Maharashtra								1549.53		-1.48	0.06	0.20	15.71				1564.01
Nagaland		8.89		22.40				-0.79			9.53					2.27	42.30
Orissa	-63.51							-2.09		-29.64						0.18	-95.06
Punjab	3.89					-31.74		62.23					8.42	-0.84		0.67	42.63
Rajasthan	-15.34					-44.99		2.36		-1.13	-1.98						-61.08
TN	27.49		4.29			-2.08	4.50	102.41	-0.71		0.29				0.36	1.73	138.28
UP	3.43					-10.11		0.22						20.96		438.16	452.65
WB	-3.84		-0.06			-16.12		-126.09	-34.77		0.00	1.84	-6.03		1.08		-183.99
Total	-120.86	8.89	13.43	128.37	0.00	-84.75	4.50	2005.48	-53.34	-35.95	-47.96	2.04	55.61	-310.34	17.32	1854.97	3437.41

Appendix 65: Inter-state VW-flows embedded in Oilseeds (in GL) (2009-2010)

Oilseeds (2009-2010)		**Exported from**																
		AP	Assam	Chhattisgarh	Delhi	Haryana	Jharkhand	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	Rajasthan	TN	UP	WB	Total
Exported to	AP							-3.38		-6.99	-7.14		-43.13			-1.19		-61.83
	Assam	-14.62		-0.12	64.21					-189.79		-20.86	-476.67	-19.89	-1005.13		-127.10	-1789.97
	Bihar							26.98		51.22				2.73		1.50	1251.20	1333.62
	Chhattisgarh	-2.30								-1.62								-3.91
	Chandigarh				16.60													16.60
	Delhi	-24.07					2.96	0.60		14.68			15.58		-41.08		50.60	19.26
	Goa												17.49					17.49
	Gujarat	-12.15								110.58			1081.11	16.27				1195.81
	Haryana									18.78		-2.76	53.01					69.03
	Jharkhand									-0.35								-0.35
	Karnataka									25.58	1.79		-0.18			0.01		27.19
	Kerala			38.69						-2.23				-1.03		72.17	38.62	146.21
	MP	-25.02				-0.60		-10.99									-3.02	-39.62
	Maharashtra	13.52		2.61						1520.27		8.12	-44.90	23.73		1.25		1524.60
	Nagaland		31.27		18.69					-0.58			282.84	1.61			46.54	380.38
	Orissa	188.10										-309.88		-1.45	-118.58		25.99	-215.82
	Punjab	20.05						407.78		64.09	-0.25			12.59	17.03			521.29
	Rajasthan	8.33						-61.11				-9.87						-62.64
	TN	4.41		1.29				-24.64	0.90	205.93	-8.62	7.04	175.81	2.86		7.51		372.49
	UP	1.49						112.61		3.64					-163.92		1449.74	1403.57
	WB	-11.13		-0.05				-73.55		-373.05	-50.24	-4.97	-0.03	-10.58		-2.87		-526.47
	Total	146.62	31.27	42.42	99.50	-0.60	2.96	374.31	0.90	1440.15	-64.46	-333.17	1060.93	26.84	-1311.68	78.37	2732.57	4326.92

Appendix 66: Inter-state VW-flows embedded in Oilseeds (in GL) (2010-2011)

Oilseeds (2010-2011)		Exported from															
		AP	Assam	Chhattisgarh	Delhi	Karnataka	Kerala	MP	Maharashtra	Nagaland	Orissa	Rajasthan	TN	Uttaranchal	UP	WB	Total
Exported to	AP			0.70				-29.24	-38.27		-10.43		-736.87				-814.10
	Assam	-40.06		-0.40	68.23			-186.04		-175.64	-3140.58	-6.60	-1564.14			-2048.76	-7093.99
	AR							-5.43									-5.43
	Bihar					-1.36		96.76								19951.04	20046.44
	Chandigarh				14.25												14.25
	Delhi	108.86				385.10					376.76					433.75	1304.47
	Goa										156.56						156.56
	Gujarat					-12.98		289.98	0.03		9921.24	93.93					10292.21
	Haryana					5302.68		34.36		-4.70	427.21		155.60			603.40	6518.55
	HP							7.72									7.72
	Jharkhand								-1.86								-1.86
	Karnataka							13.01	4.80		0.04		-1932.80		0.01		-1914.94
	Kerala			28.51				-0.19						41.05	11.87	53.64	134.88
	MP					-328.06										0.02	-328.04
	Maharashtra					-4.10		9270.89		-339.94	-674.99	89.10					8340.96
	Nagaland		170.18		19.20			-0.58			1617.53	1.61				1069.30	2877.25
	Orissa	1859.36							-2.71	-773.23		-1.45				125.66	1207.64
	Punjab	7.56						135.57				10.10					153.22
	Rajasthan							2.09		-24.23	1.45						-20.69
	TN	3.08		11.32		-32.35	1.47	48.78	-23.06			5.47			0.42		15.12
	Tripura															0.08	0.08
	UP					394.69		1.17			510.04					18303.39	19209.29
	WB	-3.13		-0.02		-84.44		-386.68	-94.63		-0.03	-15.55			6.90		-577.56
	Total	1935.67	170.18	40.11	101.68	5619.19	1.47	9292.17	-155.71	-1317.74	9184.82	176.62	-4078.20	41.05	19.20	38491.52	59522.03

Appendix 67: Inter-state VW-flows embedded in Oilseeds (in GL) (2011-2012)

Oilseeds (2011-2012)		**Exported from**													
		AP	Chhattisgarh	Delhi	Karnataka	MP	Maharashtra	Nagaland	Orissa	Rajasthan	TN	Uttaranchal	UP	WB	Total
Exported to	AP		0.24			-8.01	-84.37		-51.74	-2.53			-6.13		-152.54
	Assam		-0.12	62.85		-3.71	-18.11	-160.37	-331.98	-7.50	-157.97			-242.53	-859.44
	Bihar			0.06	-2.70	93.30	-0.33			0.00			-10.84	1504.65	1584.14
	Chandigarh			21.81											21.81
	Delhi	-44.51						75.95	61.81						93.26
	Goa								7.22						7.22
	Gujarat				-7.64	145.50	0.23		1642.61	81.42					1862.12
	Haryana	116.05			229.87	37.93		1.95	120.46		15.98				522.25
	HP			2.65		1.90	1.13								5.69
	Karnataka					12.91	3.33		0.02	0.21	-66.51		12.18	14.97	-22.89
	Kerala		53.21							-2.12	-272.59		162.21	41.82	-17.47
	MP				-11.47		-9.32								-20.79
	Maharashtra					189.55		-2.46	35.85	89.55		24.92	22.44		359.85
	Nagaland			19.58		-0.28			26.78	0.52				93.30	139.90
	Orissa	173.57						-692.34							-518.77
	Punjab	0.20			71.62	117.81				38.90					228.53
	Rajasthan							-30.83	-4.63						-35.46
	TN	9.20	23.78		-9.35	43.57	-58.79		117.00	1.87		22.51	23.52		173.32
	UP	34.26				-0.98								1094.43	1127.72
	WB	-0.79	-0.01		-48.27	-265.13	-187.83	-30.79	-0.02	-13.37			-13.51		-559.73
	Total	287.98	77.11	106.96	222.06	364.38	-354.06	-838.89	1623.38	186.94	-481.09	47.44	189.85	2506.65	3938.71

Appendix 68: Inter-state VW-flows embedded in Oilseeds (in GL) (2012-2013)

Oilseeds (2012-2013)		**Exported from**														
		AP	Chhattisgarh	Delhi	Gujarat	Karnataka	Kerala	MP	Maharashtra	Orissa	Rajasthan	TN	Uttaranchal	UP	WB	Total
Exported to	AP			0.00	0.00			-1.91	-9.93	-0.07	-2.49		46.58	-11.25		20.93
	Assam			40.03	-128.27			-7.85			-76.69				-204.38	-377.15
	Bihar				-42.54			57.19	-0.33		6.09			1.50	2286.75	2308.67
	Chhattisgarh	-8.03						-5.60								-13.63
	Chandigarh			7.80							0.99					8.79
	Delhi	-4.82			24.40											19.58
	Gujarat							658.29	0.77		20.09					679.15
	Haryana				6.97	75.80		30.02								112.80
	HP							32.55								32.55
	J & K				-16.38						-0.58					-16.96
	Jharkhand				-1.52											-1.52
	Karnataka							22.20	1.05		2.21			-31.05	-204.89	-210.49
	Kerala		-237.32					-0.19			-3.89	-276.39		-1397.77	-140.74	-2056.31
	MP				-86.36				-207.98							-294.34
	Maharashtra				-1.21			139.02			21.61			-29.34		130.08
	Nagaland			13.18							8.54				89.84	111.55
	Orissa	106.17	-0.01		-2.97										12.96	116.15
	Punjab	-0.56			685.56			251.05	-1.35		17.76					952.46
	Rajasthan								-0.90							-0.90
	TN	3.04			-0.86		-19.02	35.87	-47.28		8.02		-17.16	-615.94		-653.34
	Uttaranchal				-585.94											-585.94
	UP				160.42			0.28							669.81	830.51
	WB		-0.07		-30.41			-136.46	-125.07		-27.12			-129.42		-448.56
	Total	95.80	-237.41	61.00	-19.12	75.80	-19.02	1074.47	-391.03	-0.07	-25.47	-276.39	29.43	-2213.27	2509.35	664.07

Appendix 69: Inter-state VW-flows embedded in Oilseeds (in GL) (2013-2014)

Oilseeds (2013-2014)		**Exported from**															
		AP	Chhattisgarh	Delhi	Gujarat	Haryana	Karnataka	MP	Maharashtra	Orissa	Punjab	Rajasthan	TN	Uttaranchal	UP	WB	Total
Exported to	AP		1.15					-21.10				-6.18		47.00	-16.84		4.02
	Assam			15.21	-340.36			-5.56				-71.59				-203.51	-605.81
	Bihar				-28.65		-1.31	27.85	-0.67							2258.39	2255.62
	Chhattisgarh	-6.85															-6.85
	Chandigarh			0.04					13.01								13.05
	Delhi	-0.23															-0.23
	Gujarat							598.95	2.14			10.36					611.46
	Haryana				1339.38			22.83	1.25								1363.45
	HP		2.99														2.99
	J & K				-7.70				-1.39								-9.09
	Karnataka		14.82					5.13	7.25			13.08	6.03		49.95	29.27	125.51
	Kerala	-36.34	228.84			-8.18		-3.24	-1.76	8.60	8.60	-0.98		122.66	229.69	12.16	560.06
	MP	-0.80							-34.32								-35.12
	Maharashtra							39.06				71.66			31.38		142.10
	Nagaland			6.37								23.51				50.38	80.27
	Orissa	140.74			-1.34				-2.49								136.92
	Punjab	0.04			719.01			123.50	-0.32			16.25					858.48
	TN	9.30	33.40		-0.87		-5.64	34.80	-68.39			5.77			118.32	38.66	165.35
	Uttaranchal				-316.79												-316.79
	UP				152.00											842.50	994.49
	WB		-0.08	25.94	-138.09			-251.03	-186.83			2.43			-2.76		-550.42
	Total	105.88	281.11	47.56	1376.59	-8.18	-6.95	571.18	-272.50	8.60	8.60	64.31	6.03	169.66	409.73	3027.85	5789.48