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ΑΝΑΠΤΥΞΗΣ

Sustainability in Aquatic Ecosystems; The dynamic interaction between biological, social and economic systems: Case studies from Europe and the U.S.A.

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Γεώργιος Μαρούλης

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Τριμελής Επιτροπή

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Ευχαριστίες

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Πίνακες

Abbreviations

$. *United States Dollars*
€. *Euro*
Bgal. *Billion gallon*
BGD. *Billions gallons per day*
CA. *Capability Approach*
CARR. *Capability Approach to Regulatory Rulemaking*
CBA. *Cost-benefit Approach*
CC. *Capital Cost*
CICES. *Common International Classification of Ecosystem Services*
D. *day*
DBP. *Disinfection by-product*
DEYA. *Municipal Water Supply and Sewerage Authority- Δημοτική Επιχείρηση Ύδρευσης Αποχέτευσης*
DMV. *Deliberative Monetary Valuation*
Ecosystem Services. *Ecosystem Services*
Ecosystems Services Framework. *Ecosystems Services Framework*
ED. *Electrodialysis*
EIA. *United States Energy Information Administration*
EPA. *Environmental Protection Agency*
EPPS. *Ecosystem Properties, Potentials and Services*
EYATH. Thessaloniki Water Supply & Sewerage Utility- Εταιρία Ύδρευσης Αποχέτευσης Θεσσαλονίκης
FYROM. *Former Yugoslavic Republic of Macedonia*
G.N.I. *Gross National Income*
gal. *Gallon*
GOEB. *General Land Reclamation Organisation- Γενικός Οργανισμός Εγγείων Βελτιώσεων*
km^2. *square kilometers*
kW. *kilowatt*
kWh. *kilowatt per hour*
m^3. *cubic meter*
MA. *Millenium Ecosystem Assessment*
MAF. *Million-acre feet*
MCL. *Miaximum Contaminant Level*
MDGs. *Millenium Development Goals*
MED. *Multiple Effect Distillation*
MEEC. *Ministry of Environment, Energy and Cliamte Change*
Mgal. *Million gallons*
MGD. *Million gallons per day*
mm. *milimeter*
MMBTU. *Millions of British Thermal Units*
MSF. *Multistage Flahs Distillation*
MW. *Megawatt*
NEPA. *National Environmental Policy Act*
NF. *Nanofiltration*
NGCC. *Natural Gas Combined Cycle*
NRC. National Research Council
NRF. *National Reference Framework*
OEM. *Operational and Maintance Cost*
P. *Population*
PES. *Payments for Ecosystem Services*

POTW. *Public Owned Wastewater Treatment Plants*
PPC. *Public Power Corporation S.A-Δημόσια Επιχείρηση Ηλεκτρισμού ΔΕΗ Α.Ε.>*
PWS. *Publicly Owned Water Systems*
RBD. *River Basin District*
RBMP. *River Basin Management Plan*
RO. *Reverse Osmosis*
SAGD. *Steam-assisted gravity drainage*
SDGs. *Sustainable Development Goals*
SEEA. *System of Environmental Economic Accounting*
SMS. *Safe Minimum Standards*
SWOT. *Strenghts, Weaknesses, Opportunities and Challenges*
TCF. *Trillion cubic feet*
TDS. *Total Dissolved Solids*
TEEB. *Economics of Ecosystems and Biodiversity*
TNC. *Transnational Corporation*
TOEB. *Local Land Reclamation Organisations- Τοπικός Οργανισμός Εγγείων Βελτιώσεων*
TWh. *terawatt per hour*
U.S. DOE.. *United States Department of Energy*
UNCED. *United Nations Conference on Environment and Development*
UNCSD. *United Nations Conference on Sustainable Development*
UNEP. United Nations Environment Programme
US EPA. *US Environmental Protection Agency*
USA. *United States Of America*
USDA. *United States Department of Agriculture*
USGS. *United States Geological Survey*
Water Framework Directive. *Water Framework Directive*
WBMP. *Water Basin Management Plans*
WD. *Water Districts*
WSSD. *World Summit on Sustainable Development*
WWF. *World Wildlife Fund*
WWTP. *Wastewater Treatment Plant*
ΙΝΑΣΟ. *Institute of Agricultural and Cooperative Economy- Ινστιτούτο Αγροτικής και Συνεταιριστικής Οικονομίας*

Βιώσιμη ανάπτυξη στα υδατικά οικοσυστήματα: Η δυναμική αλληλεξάρτηση μεταξύ βιολογικού, κοινωνικού και οικονομικού συστήματος. Εφαρμογή στην Ευρώπη και στις ΗΠΑ.

Εκτενής Περίληψη

Εισαγωγή

Σκοπός της διδακτορικής διατριβής είναι η περιγραφή και η ανάλυση της βιώσιμης ανάπτυξης μέσω της διαγενειακής και ενδογενειακής δικαιοσύνης. Βάσει της ανάλυσης αυτής, θα αποδειχθεί ότι οι έννοιες όπως το πλαίσιο υπηρεσιών για τα οικοσυστήματα (ESF) και ανάλυση της σχέσης νερού-ενέργειας μπορούν να εξηγήσουν επαρκώς τον τρόπο με τον οποίο επιτυγχάνεται η βιωσιμότητα στα υδρόβια οικοσυστήματα. Επομένως, το κυριότερο ερευνητικό ερώτημα είναι: Πώς μπορεί να επιτευχθεί η βιώσιμη ανάπτυξη στα υδρόβια οικοσυστήματα; Είναι μια έννοια ή μια θεωρία επαρκής για να περιγράψει τη βιωσιμότητα αυτών των οικοσυστημάτων;

Ο τίτλος της διπλωματικής εργασίας περιγράφει τόσο τα κύρια ερευνητικά ερωτήματα όσο και την ερευνητική διαδικασία. Επομένως, η έρευνα αποτελείται από τρία κρίσιμα βήματα, τα οποία αναμένεται να ακολουθηθούν προσεκτικά, ώστε να επιτευχθεί η πρωταρχική υπόθεση, δηλαδή πώς μπορεί να επιτευχθεί η βιωσιμότητα.

Πρώτον, θα αναλυθεί η βιώσιμη ανάπτυξη των υδατικών οικοσυστημάτων. Στόχος είναι να θέσει τις βάσεις που θα διευκολύνουν τη διαδικασία της έρευνας. Κατά συνέπεια, θα πρέπει να εξετάσουμε διεξοδικά την βιώσιμη ανάπτυξη και τη βιωσιμότητα. Πιο συγκεκριμένα, θα γίνει μια λεπτομερής περιγραφή για την αειφόρο ανάπτυξη. Εκτός από την παρουσίαση μιας γενικής εικόνας για την αειφόρο ανάπτυξη και τη βιωσιμότητα, η προσοχή θα επικεντρωθεί στα συγκεκριμένα χαρακτηριστικά της βιωσιμότητας που θα βοηθήσουν στην ανάπτυξη ενός πλαισίου για την περιγραφή της επίτευξης του μέσα στα υδατικά οικοσυστήματα.

Δεύτερον, θα παρουσιαστεί η δυναμική αλληλεπίδραση μεταξύ της οικονομικής, κοινωνικής και περιβαλλοντικής/ βιολογικής διάστασης. Εδώ πρόκειται περισσότερο για μια εξειδίκευση του ορισμού της βιώσιμης ανάπτυξης και της βιωσιμότητας, κάτι στο οποίο έγκειται η πολυπλοκότητα της βιώσιμης ανάπτυξης σε σύγκριση με άλλες έννοιες και θεωρίες. Θεωρείται ότι η βιώσιμη ανάπτυξη ορίζεται ως "ανάπτυξη που ανταποκρίνεται στις ανάγκες του παρόντος χωρίς να διακυβεύεται η ικανότητα των μελλοντικών γενεών να καλύψουν τις δικές τους ανάγκες", όπως ορίζεται στην έκθεση Brundtland (WCED, 1987). Αυτός ο ορισμός είναι ανοικτός σε διάφορες αναγνώσεις, οι οποίες είναι επωφελείς για την επιστημονική έρευνα, αλλά δημιουργούν διαφωνίες σχετικά με την εφαρμογή μιας αντίστοιχης πολιτικής. Η έρευνα πρόκειται να επωφεληθεί από τη διφορούμενη φύση της βιώσιμης ανάπτυξης, αλλά η έρευνα δεν θα περιοριστεί στο κλασικό «δίπολο» της «αδύναμης-ισχυρής» προσέγγισης της βιώσιμης ανάπτυξης. Θα ακολουθηθεί ένας άλλος δρόμος όπου θα εξεταστούν και άλλες επιστήμες για να βρεθεί η αλληλεπίδραση της οικονομικής, κοινωνικής και περιβαλλοντικής διάστασης για την επίτευξη της βιώσιμης ανάπτυξης. Αυτοί οι άλλοι επιστημονικοί κλάδοι έχουν μελετήσει εδώ και καιρό άλλα θέματα που σχετίζονταν κυρίως με το άτομο, την ανθρώπινη ευημερία και τη δικαιοσύνη. Με την εξέταση τέτοιων ζητημάτων προέκυψε το ζήτημα της βιώσιμης ανάπτυξης. Παρακάτω η επιλογή αυτή θα αιτιολογηθεί λεπτομερώς. Ωστόσο, μπορεί να αναφερθεί ένα συγκεκριμένο και κοινό χαρακτηριστικό αυτών των κλάδων και της έννοιας της βιωσιμότητας. Αυτή είναι η ύπαρξη ανθρώπων που καθορίζουν και δίνουν αξία στη φύση. Εάν δεν υπήρχαν θεωρητικά ανθρώπινα όντα, τότε δεν θα χρειαζόταν να χρησιμοποιούμε διαφορετικές θεωρίες για τα άτομα, την κοινωνία, την οικονομία και τη σχέση τους με τη φύση.

Τρίτον, θα αναλυθούν μελέτες περιπτώσεων από την Ευρώπη και τις Ηνωμένες Πολιτείες. Δεδομένου ότι η βιώσιμη ανάπτυξη δημιουργήθηκε ως αλληλεπίδραση μεταξύ κοινωνικού, οικονομικού και περιβαλλοντικού συστήματος, το αποτέλεσμα θα ήταν ένα πλαίσιο βάσει του οποίου μπορεί να αξιολογηθεί η επίτευξη της βιωσιμότητας. Επομένως, το αποτέλεσμα αυτής της θεωρητικής ανάλυσης πρέπει να είναι μια έννοια, μια προσέγγιση ή ακόμα και μια μονάδα μέτρησης. Αυτό θα βοηθήσει στην επίλυση του κύριου ερευνητικού ζητήματος, δηλαδή στην επίτευξη της βιωσιμότητας. Ένα βασικό ερώτημα είναι αν μια μονάδα μέτρησης ή μια προσέγγιση είναι αρκετή για να εξηγήσει το κύριο ερευνητικό ερώτημα. Ενδεχομένως, μια προσέγγιση δεν είναι επαρκής και μπορούν να χρησιμοποιηθούν πολλαπλά πλαίσια για να ελέγξουν την πρωταρχική υπόθεση. Τέτοιες προσεγγίσεις θα πρέπει σε κάθε περίπτωση να είναι συγκεκριμένες και θα ήταν χρήσιμο σίγουρα εάν αυτές μπορούν να γενικοποιηθούν, δηλαδή εάν αυτές εφαρμόζονται σε όλες σχεδόν τις περιπτώσεις. Τα αποτελέσματα αυτών των αναλύσεων θα δείξουν την επιτυχία τους. Η επιτυχία δεν μπορεί να είναι αντικειμενική. Αυτό δεν σημαίνει ότι αυτές οι έννοιες πρέπει να απορριφθούν. Αντίθετα, τα αποτελέσματα μπορούν να ρίξουν φως σε συγκεκριμένα στοιχεία της βιωσιμότητας και να αναλυθούν και να χρησιμοποιηθούν ανάλογα. Αυτά τα αποτελέσματα δείχνουν πώς αυτά μπορούν να χρησιμοποιηθούν σε μια μελλοντική εφαρμογή πολιτικής είναι επίσης ένα θέμα, το οποίο θα μπορούσε να περιγραφεί περαιτέρω. Εν γένει, μπορεί να θεωρηθεί ότι αυτή η διδακτορική διατριβή αναμένει να χρησιμοποιήσει τα αποτελέσματα των αναλύσεων για να απαντήσει στο κύριο ερευνητικό ερώτημα και να εξηγήσει τον πολύπλευρο χαρακτήρα της βιώσιμης ανάπτυξης.

Βασικά ερωτήματα της διδακτορικής διατριβής

Σχετικά με τα επιμέρους ερωτήματα παρακάτω γίνεται μια ενδελεχή περιγραφή των βασικών ερωτήσεων και των επιμέρους ζητημάτων που θα εξεταστούν.

Όπως εξηγήθηκε παραπάνω, η βιώσιμη ανάπτυξη έχει οριστεί ως "ανάπτυξη που ανταποκρίνεται στις ανάγκες του παρόντος χωρίς να διακυβεύεται η ικανότητα των μελλοντικών γενεών να καλύψουν τις δικές τους ανάγκες" (WCED, 1987).

Αυτό μπορεί να θεωρηθεί ως ο πιο διάσημος ορισμός της αειφόρου ανάπτυξης. Ένα εύλογο ερώτημα που προκύπτει μετά από αυτή τη σύντομη περιγραφή είναι τι είχε συμβεί πριν από την εμφάνιση αυτού του ορισμού. Μήπως η έννοια της "βιώσιμης ανάπτυξης" βγήκε έτσι ξαφνικά; Ήταν αυτή η νεοπαγής όρος ήταν αποτέλεσμα της πολιτικής εμπειρίας των προηγούμενων δεκαετιών; Αποτελούσε στόχος της ήταν να συνοψίσει και να συμπεριλάβει ήδη εφαρμοσμένες έννοιες και θεωρίες; Πού θα μπορούσε να βρεθεί η προέλευσή αυτής της έννοιας. Συνεπώς, θα πρέπει να παρουσιαστούν οι ιστορικές ρίζες του όρου "βιωσιμότητα" και "βιώσιμη ανάπτυξη". Επιπλέον, ένα άλλο ερώτημα που ανακύπτει είναι ο τρόπος με τον οποίο ο όρος αυτός ερμηνεύθηκε και αναλύθηκε έτσι ώστε να καταλήξει ως γενικός στόχος πολιτικής. Γιατί διατυπώθηκε ένας τέτοιος ορισμός; Τι έκανε τους διαμορφωτές πολιτικής και την επιστημονική κοινότητα να καθορίσουν αυτή την έννοια;

Πέρα από αυτό, ένα άλλο πρωταρχικό ζήτημα είναι ο τρόπος με τον οποίο ο ορισμός της βιώσιμης ανάπτυξης χρησιμοποιήθηκε και εφαρμόστηκε. Ο όρος διατηρεί τα βασικά στοιχεία του; Πώς συνέβαλε ως κύριος στόχος πολιτικής; Μήπως η θέση της έννοιας αυτής αποδυναμώθηκε ή ενισχύθηκε τα τελευταία χρόνια; Ως εκ τούτου, πρέπει να αναλυθεί η εξέλιξη και η εφαρμογή της έννοιας της αειφόρου ανάπτυξης κατά τα τελευταία 20 χρόνια, από τη δημοσίευση της Επιτροπής του Brundtland το 1987.

Εκτός αυτού, το δεύτερο ερώτημα αφορά τη δυναμική αλληλεπίδραση μεταξύ οικονομικής, κοινωνικής και περιβαλλοντικής διάστασης. Αυτό είναι βασικά μια εξειδίκευση του ορισμού της βιώσιμης ανάπτυξης. Μία από τις παραπάνω υποθέσεις είναι ότι ο όρος αειφόρος ανάπτυξη είναι ανοικτός σε πολλές ερμηνείες. Κατά συνέπεια, το επόμενο ερώτημα που ανακύπτει είναι η ερμηνεία της βιώσιμης ανάπτυξης που θα πρέπει να επιχειρήσει να αναλύσει αυτή η διδακτορική διατριβή. Επιπλέον, πώς μπορεί να εξηγηθεί αυτή η επιλογή; Ποιες είναι οι παράμετροι που κατευθύνουν την έρευνα σε αυτό;

Έτσι θα ακολουθηθεί μια πιο εναλλακτική διαδικασία. Αυτό οφείλεται κυρίως στο γεγονός ότι φαίνεται να υπάρχει αυξανόμενο ενδιαφέρον από άλλους κλάδους για το θέμα της βιώσιμης ανάπτυξης. Σε πρώτο στάδιο, θα επιχειρηθεί η ερμηνεία της βιώσιμης ανάπτυξης μέσω του επιστημονικού πεδίου της διαγενειακής δικαιοσύνης. Οι επιστήμες όπως η πρακτική φιλοσοφία, η οικονομία και η κοινωνιολογία έχουν επικεντρώσει την έρευνά τους στο θέμα αυτό και έχουν αποτελέσει αντικείμενο έρευνας για πολλούς επιστημονικούς κλάδους σύμφωνα με την αντίστοιχη επιστημονική τους παράδοση.

Υπάρχουν συγκεκριμένα επιχειρήματα όσον αφορά την επιλογή αυτής. Ένα βασικό επιχείρημα υπέρ αυτής της επιλογής αφορά τη φύση της βιωσιμότητας. Η βιώσιμη ανάπτυξη σχετίζεται περισσότερο ή λιγότερο άμεσα με ζητήματα που σχετίζονται με το περιβάλλον και τη ρύπανση. Παρ 'όλα αυτά, υπάρχει επίσης η οικονομική και κοινωνική διάσταση που πρέπει να ληφθεί υπόψη. Σίγουρα, η έμφαση στο περιβάλλον ήταν βασικά η «πολιτική καινοτομία» που έκανε την αειφόρο ανάπτυξη μια μοναδική ιδέα (Grober, 2007). Ωστόσο, μπορεί να υποστηριχθεί ότι η βιώσιμη ανάπτυξη είναι ένα ζήτημα αλληλεπίδρασης και αλληλεξάρτησης μεταξύ αυτών των τριών συστημάτων. Πιο συγκεκριμένα, η βιώσιμη ανάπτυξη επικεντρώνεται στην αλληλεπίδραση μεταξύ ανθρώπων και φύσης. Τα ανθρώπινα όντα είναι αυτά που εκμεταλλεύονται και χρησιμοποιούν τη φύση και τους πόρους της προς όφελός τους. Κατά συνέπεια, η ύπαρξη ανθρώπων είναι ο «λόγος ύπαρξης» πίσω από την βιώσιμη ανάπτυξη. Εάν δεν υπήρχαν άνθρωποι, δεν θα χρειαζόταν να κοιτάζουμε το περιβάλλον. Ως εκ τούτου, εστιάζεται στις αλληλεπιδράσεις μεταξύ αυτών των τριών συστημάτων. Επιπλέον, το περιβάλλον θεωρείται ως το "μέσο για ένα συγκεκριμένο σκοπό", βάσει του οποίου ικανοποιούνται οι ανάγκες των ανθρώπων. Σε τελική ανάλυση, η ικανοποίηση των αναγκών και η επίτευξη της ευημερίας (σε επαρκές επίπεδο) που εξαρτάται από το περιβάλλον και τους πόρους της, βρίσκεται στον πυρήνα της βιώσιμης ανάπτυξης.

Θα ήταν χρήσιμο να εξεταστούν άλλοι κλάδοι που έχουν ασχοληθεί με ζητήματα που αφορούν τη διαγενειακή δικαιοσύνη, δηλαδή τη δικαιοσύνη μεταξύ των γενεών. Βασικά ερωτήματα που σχετίζονται με τη διαγενειακή δικαιοσύνη είναι πόσο και πώς πρέπει να διατηρήσουμε για την επόμενη γενιά; "Αν απαντηθούν αυτά τα ερωτήματα τότε μπορεί να απαντηθεί επαρκώς το ερευνητικό ερώτημα. Πιο συγκεκριμένα, το κύριο ζήτημα είναι κυρίως δεοντολογικό. Με άλλα λόγια, εάν η σημερινή γενιά πρέπει να κληρονομήσει κάτι στην επόμενη γενιά, πώς και πόσο;

Η απάντηση σε αυτό το ερώτημα δεν είναι απλή, λόγω του γεγονότος ότι η βιωσιμότητα εισέρχεται στην εξίσωση της διαγενειακής δικαιοσύνης. Είναι πρωταρχικό ζήτημα να εντοπιστεί μια θεωρία που περιγράφει πώς τουλάχιστον ένα ελάχιστο επίπεδο ευημερίας, ένα κατώφλι μπορεί να κληροδοτηθεί στην επόμενη γενιά από την προηγούμενη γενιά.

Μετά την παρουσίαση μιας συνολικής προσέγγισης σχετικά με τον τρόπο με τον οποίο η βιωσιμότητα μπορεί να ενσωματωθεί στο πλαίσιο της διαγενειακής δικαιοσύνης, το επόμενο ερώτημα πρέπει να στοχεύει στην ανάλυση ενός συγκεκριμένου χαρακτηριστικού της έννοιας της βιώσιμης ανάπτυξης. Αυτό είναι το κρίσιμο θέμα της ικανοποίησης των ανθρώπινων βασικών αναγκών. Το ερώτημα μπορεί να συνοψιστεί ως εξής: τι θεωρούν τα ανθρώπινα όντα ως σημαντικό για τη δική τους ευημερία, που είναι επομένως ζωτικής σημασίας για τη διατήρηση και την κληρονομιά των επόμενων γενεών; Επιπλέον, ένα άλλο ερώτημα μπορεί να είναι εάν υπάρχουν συγκεκριμένες ανάγκες που πρέπει να ικανοποιηθούν για να επιτευχθεί ένα άτομο ένα ορισμένο «κατώφλι» ευημερίας ».

Κατά συνέπεια, το επόμενο ερώτημα που τίθεται είναι το πώς ορίζεται αυτό το όριο για αυτό το άτομο. Υπάρχουν θεωρίες που καθορίζουν τις βασικές ανάγκες ενός ανθρώπου;

Μετά την ανάλυση της έννοιας της βιωσιμότητας και την εξέταση της έννοιας της ευημερίας σε ενδογενεακό επίπεδο, η ανάλυση στοχεύει να επικεντρωθεί σε έννοιες και μετρήσεις που σχετίζονται άμεσα ή έμμεσα με την αειφόρο ανάπτυξη. Υπάρχει μια τέτοια μέτρηση; Πώς εκφράζεται η βιωσιμότητα στο πλαίσιο αυτό και πώς αξιολογείται η ευημερία;

Κύριος στόχος της ερευνητικής διαδικασίας είναι να επικεντρωθεί στο πλαίσιο των υπηρεσιών για τα οικοσυστήματα (Ecosystem Services ES). Ο λόγος για την εξέταση αυτής της έννοιας βασίζεται στο γεγονός ότι μπορεί κανείς θεωρητικά να δει το οικοσύστημα, τις υπηρεσίες ως μέσο με το οποίο μπορεί να επιτευχθεί η «ευημερία». Εκτός από αυτό, είναι επίσης προφανές ότι το πλαίσιο υπηρεσιών οικοσυστημάτων ενσωματώνει τόσο την βιωσιμότητα όσο και την ευημερία.

Κύρια έμφαση πρέπει να δοθεί στο πώς η εφαρμογή πλαισίου για τις οικοσυστημικές υπηρεσίες διασφαλίζει την ευημερία και πώς μπορούν να εξασφαλίσουν την ικανοποίηση της ανθρώπινης ευημερίας.

Το τελευταίο στάδιο της έρευνας είναι η πρακτική εφαρμογή του πλαισίου των οικοσυστημικών υπηρεσιών ή ακόμα και άλλων εννοιών που επικεντρώνονται στη βιωσιμότητα. Το πρώτο ερώτημα που τίθεται είναι εάν υπάρχει μια μελέτη περίπτωσης για το πώς μπορεί να εκτιμηθούν οι υπηρεσίες οικοσυστήματος και να αποτιμηθεί η αξία τους. Επιπλέον, ένα άλλο θέμα του είναι βασικά πώς μπορούν να εφαρμοστούν στην πράξη οι υπηρεσίες οικοσυστήματος, πώς μπορούν οι υφιστάμενες έννοιες και πολιτικές να συμβάλουν στη διαμόρφωση της αξίας των υπηρεσιών οικοσυστήματος και πώς μπορεί να χρησιμοποιηθεί περαιτέρω για τη χάραξη πολιτικής.

Ωστόσο, χρειάζεται μια ακόμη σημαντική προσθήκη για να προχωρήσουμε σε αυτή την αναλυτική διαδικασία. Αυτή η προσθήκη αφορά την αναζήτηση του βασικού θεωρητικού πλαισίου. Αυτή η βάση θα αποτελέσει τον βασικό πυλώνα και θα υποστηρίξει μια τέτοια ανάλυση. Παράλληλα, επιδιώκεται να υπάρχουν περισσότερες από μία έννοιες, με τις οποίες τα σχέδια διαχείρισης λεκάνης απορροής μπορούν να αναδιατυπωθούν έτσι ώστε να αποτελέσουν τη βάση για την πρακτική εφαρμογή των υπηρεσιών οικοσυστήματος.

Λόγω του γεγονότος ότι η βιώσιμη ανάπτυξη και η βιωσιμότητα δεν είναι μια σταθερά οριζόμενη έννοια, αυτή η διδακτορική διατριβή φιλοδοξεί να εκμεταλλευτεί αυτή την ασάφεια και να παρουσιάσει μια περαιτέρω προσέγγιση που άμεσα συνυφασμένη με τον όρο αυτό. Ως εκ τούτου, η ανάλυση θα ολοκληρωθεί με την περιγραφή του παραδείγματος του νερού-ενέργειας. Η σχέση ύδατος-ενέργειας περιγράφηκε για πρώτη φορά από τον Peter Gleick (1994), καθώς το νερό χρησιμοποιείται για την παραγωγή ενέργειας, ενώ η ενέργεια χρησιμοποιείται επίσης για πολλές πτυχές του νερού, όπως η παραγωγή και η επεξεργασία. Το κύριο ερώτημα θα είναι βασικά πώς μπορεί να οριστεί ο δεσμός ύδρευσης και πώς μπορεί να περιγραφεί αυτό. Επιπλέον, μπορεί αυτό το παράδειγμα να συμβάλει στον σχεδιασμό πολιτικών για το νερό και την ενεργειακή αποδοτικότητα που μπορούν να εξασφαλίσουν τη βιωσιμότητα των υδάτινων πόρων αφενός και την αποδοτική και καθαρή παραγωγή ενέργειας αφετέρου; Τέλος, υπάρχουν κάποια διδάγματα;

Η διδακτορική διατριβή ολοκληρώνεται με μια συζήτηση για την έρευνα που παρουσιάζεται σε όλα τα βήματα. Εδώ το βασικό ερώτημα είναι αν οι ερωτήσεις για κάθε αντίστοιχο θέμα έχουν αντιμετωπιστεί με επιτυχία και εάν οι βασικές παραδοχές έχουν επικυρωθεί. Αυτό σημαίνει ότι το βασικό ερώτημα θα μπορούσε θεωρητικά και πρακτικά να επικυρωθεί. Με άλλα λόγια, διατυπώθηκε με επιτυχία η αειφόρος ανάπτυξη; Μήπως οι ιδέες από τη δικαιοσύνη μεταξύ και γενεών βοηθούν στη διαμόρφωση της βιώσιμης ανάπτυξης; Η πρακτική εφαρμογή από την Ευρώπη και τις Η.Π.Α. συνέβαλε σε αυτόν τον στόχο; Αναμένεται να αντιμετωπιστεί το βασικό ερευνητικό ερώτημα. Ασφαλώς, δεν μπορεί να υπάρξει μόνο απάντηση σε αυτά τα ερωτήματα και η έρευνα ακολουθεί μια εναλλακτική προσέγγιση. Μια τέτοια εναλλακτική άποψη θα στοχεύει στον εμπλουτισμό της επιστημονικής συζήτησης σχετικά με αυτόν τον τομέα της έρευνας και θα ανοίξει νέα ερευνητικά ερωτήματα για το μέλλον.

Το **Κεφάλαιο 1** αποτελεί την εισαγωγή της διδακτορικής διατριβής. Εκεί παρουσιάζονται τα βασικά ερωτήματα, τη μοναδικότητα της διατριβής αυτής, τα προβλήματα που επρόκειτο να ανακύψουν καθώς και τα προσδοκώμενα αποτελέσματα.

Το **Κεφάλαιο 2** παρουσιάζει μια διεξοδική ανάλυση της βιώσιμης ανάπτυξης. Πρώτον, παρουσιάζονται οι ιστορικές ρίζες του όρου βιωσιμότητα και βιώσιμη ανάπτυξη. Δεύτερον, περιγράφεται η διαδικασία εισαγωγής του όρου στην ατζέντα πολιτικής. Τρίτον, εξετάζεται η εξέλιξη και η εφαρμογή της έννοιας της βιώσιμης ανάπτυξης τα τελευταία 20 χρόνια από την δημοσίευση της Επιτροπής Brundtland το 1987.

Το **Κεφάλαιο 3** είναι αφιερωμένο στη δικαιοσύνη μεταξύ γενεών. Το κεφάλαιο ξεκινά με μια σύντομη εισαγωγή του όρου "δικαιοσύνη μεταξύ γενεών". Τι είναι και δεν είναι η δικαιοσύνη μεταξύ των γενεών σύμφωνα με τον τελευταίο επιστημονικό διάλογο; Στη συνέχεια, το επόμενο κεφάλαιο θα αφιερωθεί στον John Rawls και την προσπάθειά του να εξηγήσει και να διαμορφώσει μια θεωρία της δικαιοσύνης μεταξύ γενεών. Επιπλέον, η θεωρία του Rawls εξετάζεται με τέτοιο τρόπο ώστε τα στοιχεία από τη θεωρία να αξιοποιηθούν τελικά, έτσι ώστε η ρητή βιωσιμότητα να μπορεί να εκφραστεί με όρους δικαιοσύνης μεταξύ γενεών. Το κεφάλαιο αυτό θα βασιστεί στην υπόθεση του Axel Gosseries ότι η βιωσιμότητα μπορεί να μεταφραστεί ως «επαρκιστική αρχή» (sufficientary principle).

Το **Κεφάλαιο 4** περιγράφεται η ενδογενειακή δικαιοσύνη. Το κεφάλαιο ξεκινά με μια λεπτομερή περιγραφή της προσέγγισης του Amartya Sen, που είναι γνωστή ως «Προσέγγιση των Δυνατοτήτων»- “Capability Approach” με τα βασικά χαρακτηριστικά του. Παρόμοια με αυτή την προσέγγιση, θα παρουσιαστεί και η προσέγγιση της Martha Nussbaum σχετικά με τις βασικές ανάγκες, καθώς και οι δύο επιστήμονες έχουν ξεκινήσει από κοινού την ανάπτυξη αυτής της προσέγγισης. Ωστόσο, η Nussbaum επέλεξε μια πιο αποφασιστική ανάλυση των βασικών αναγκών. Επιπλέον, περιγράφεται η προσέγγιση του Max Neef σχετικά με τις βασικές ανάγκες. Σε αντίθεση με τους άλλους δύο, ο Max Neef ενδιαφέρεται να παρουσιάσει μια πολύ λεπτομερή και πλήρη λίστα βασικών αναγκών που ικανοποιούν την ευημερία ενός ατόμου. Το κεφάλαιο ολοκληρώνεται παρουσιάζοντας τρεις προσεγγίσεις που προσπαθούν να συγχωνεύσουν στοιχεία και των τριών προσεγγίσεων ενώ προσπαθούν να ενσωματώσουν τη βιωσιμότητα ρητά ή έμμεσα.

Το **Κεφάλαιο 5** εισάγει το Πλαίσιο Υπηρεσιών για τα Οικοσυστήματα (Ecosystem Services Framework). Πρώτον, παρουσιάζεται μια σύντομη παρουσίαση του πλαισίου υπηρεσιών για τα οικοσυστήματα. Πιο συγκεκριμένα, περιγράφονται τα βασικά χαρακτηριστικά, ο σκοπός, η κατηγοριοποίηση και η ανάπτυξη κατά τα τελευταία δεκαπέντε χρόνια. Η εστίαση βασίζεται βασικά στον τρόπο με τον οποίο εκφράζεται η βιωσιμότητα στο πλαίσιο και στον τρόπο αξιολόγησης της ευημερίας. Για το λόγο αυτό, σκιαγραφείται η εφαρμογή του πλαισίου των οικοσυστημικών υπηρεσιών. Δεύτερον, αναλύεται ένα συγκεκριμένο χαρακτηριστικό του πλαισίου. Αυτό το χαρακτηριστικό είναι η έννοια της δικαιοσύνης. Εκφραζόμενοι με όρους "ευημερίας", θα δούμε πώς η εφαρμογή του πλαισίου αυτού διασφαλίζει την ευημερία και πώς μπορούν να εξασφαλίσουν την ικανοποίηση της βιωσιμότητας που εκφράζεται στο προηγούμενο κεφάλαιο.

Το **Κεφάλαιο 6** παρουσιάζει την πρώτη περίπτωση μελέτης. Το κεφάλαιο ξεκινά με μια σύντομη εισαγωγή της οδηγίας πλαισίου για τα ύδατα. Στη συνέχεια, παρουσιάζεται το βασικό θεωρητικό πλαίσιο. Το κύριο μέρος του κεφαλαίου είναι αφιερωμένο στην εμπεριστατωμένη οικονομική αποτίμηση των υπηρεσιών οικοσυστήματος υδάτων στις περιοχές των υδάτων της Κεντρικής και Δυτικής Μακεδονίας. Η βασική έρευνα διεξάγεται στο πλαίσιο της σύνθεσης των Σχεδίων Διαχείρισης Λεκάνης Απορροής Υδάτων για τα Υδατικά Διαμερίσματα Κεντρικής (ΥΔ10) και Δυτικής Μακεδονίας (ΥΔ09) και ειδικότερα της οικονομικής αποτίμησης και του λόγου ανάκτησης κόστους για όλες τις χρήσεις νερού. Το επόμενο βήμα είναι να χρησιμοποιήσουμε αυτές τις αξίες για να αξιολογήσουμε την αξία συγκεκριμένων υπηρεσιών οικοσυστήματος που σχετίζονται με το νερό. Η ανάλυση αποτελεί την πρώτη του είδους της Ελλάδας.

Στο **Κεφάλαιο 7** παρουσιάζεται η δεύτερη μελέτη περίπτωσης. Το κύριο μέρος του κεφαλαίου είναι αφιερωμένο σε μια διεξοδική ανάλυση της σχέσης νερού-ενέργειας (water- energy nexus) και των πολύπλευρων πτυχών αυτής της σχέσης. Το επίκεντρο της ανάλυσης θα είναι οι Ηνωμένες Πολιτείες της Αμερικής (ΗΠΑ), όπου η έννοια έχει εξεταστεί λεπτομερώς. Πιο συγκεκριμένα, διερευνούνται δύο βασικές κατηγορίες: νερό για ενέργεια και ενέργεια για το νερό. Επιπλέον, θα περιγραφεί μια πτυχή του δεσμού ενέργειας-νερού. Αυτή αφορά την αφαλάτωση του νερού. Παρά το γεγονός ότι η αφαλάτωση του νερού έχει επί του παρόντος πολύ οριακό ρόλο στη σχέση ύδατος-ενέργειας, αναμένεται ότι θα έχει αναδυόμενη σημασία στο εγγύς μέλλον.

Συνολικά, μπορεί να θεωρηθεί ότι όλα τα ερευνητικά ερωτήματα αντιμετωπίστηκαν επαρκώς. Επιπλέον, η ερευνητική διαδικασία έχει προσθέσει σημαντικές γνώσεις και πολλά χαρακτηριστικά θα μπορούσαν να αξιοποιηθούν περαιτέρω, ώστε να συμβάλουν περαιτέρω στον επιστημονικό διάλογο.

Ανάλυση- συμπεράσματα της διδακτορικής διατριβής

Όπως αναφέρθηκε παραπάνω, η έρευνα αποτελείται από τρία κρίσιμα βήματα, τα οποία αναμένεται να ακολουθηθούν προσεκτικά, ώστε να επιτευχθεί η πρωταρχική υπόθεση, δηλαδή πώς μπορεί να επιτευχθεί η βιωσιμότητα. Έτσι θα παρουσιαστεί παρακάτω μια σύντομη περιγραφή και ανάλυση στα ερωτήματα που τέθηκαν.

Βιώσιμη ανάπτυξη στα υδατικά οικοσυστήματα

Σε με την πρώτη πρόταση του τίτλου της διδακτορικής διατριβής, διατυπώθηκαν διάφορα ερευνητικά ερωτήματα. Πρώτον, τι είχε συμβεί πριν εμφανιστεί αυτός ο ορισμός. Μήπως η έννοια της "βιώσιμης ανάπτυξης" εμφανίστηκε ξαφνικά; Ήταν αυτός ο νεοσυσταθείς όρος αποτέλεσμα της πολιτικής εμπειρίας των προηγούμενων δεκαετιών; Είχε ως στόχο να συνοψίσει και να συμπεριλάβει ήδη εφαρμοσμένες έννοιες και θεωρίες; Πού θα μπορούσε να βρεθεί η προέλευσή της;

Επιπλέον, ένα άλλο ερώτημα που ανακύπτει είναι ο τρόπος με τον οποίο ο όρος αυτός ερμηνεύθηκε και αναλύθηκε έτσι ώστε να καταλήξει ως γενικός στόχος πολιτικής. Γιατί διατυπώθηκε ένας τέτοιος ορισμός; Τι παρότρυνε τους διαμορφωτές πολιτικής και την επιστημονική κοινότητα να καθορίσουν αυτή την έννοια;

Τέλος, ένα άλλο πρωταρχικό ζήτημα είναι ο τρόπος με τον οποίο ο ορισμός της βιώσιμης ανάπτυξης χρησιμοποιήθηκε και εφαρμόστηκε. Ο όρος διατηρεί τα βασικά στοιχεία του;

Πώς συνέβαλε ως κύριος στόχος πολιτικής; Μήπως η θέση της αποδυναμώθηκε ή ενισχύθηκε τα τελευταία χρόνια;

Ένα από τα πιο ενδιαφέροντα συμπεράσματα ήταν ότι η έννοια της αειφόρου ανάπτυξης δεν γεννήθηκε με την επονομαζόμενη "έκθεση Brundtland" το 1987. Οι ρίζες της βιώσιμης ανάπτυξης και της βιωσιμότητας χρονολογούνται από τον 17ο αιώνα. Είναι ενδιαφέρον ότι ο όρος χρησιμοποιήθηκε λειτουργικά στον τομέα της δασοκομίας και ήταν το κυρίαρχο δόγμα για δύο αιώνες τώρα. Αλλά μέχρι την μεταπολεμική εποχή, όπου ο όρος διέφυγε από τα περιοριστικά όρια της δασοπονίας και απέκτησε μια πιο ευρεία χρήση. Ο ορισμός του, όπως είναι ευρέως γνωστός, είναι περισσότερο ή λιγότερο, η αποδοχή του όρου ως πολιτικού στόχου και η επιτυχής εισαγωγή του στην ατζέντα πολιτικής, που περιμένει να εφαρμοστεί.

Ο ορισμός της βιώσιμης ανάπτυξης ως έννοια από επιστημονική άποψη άνοιξε το δρόμο για την εισαγωγή του όρου σε ένα πλαίσιο πολιτικής. Εκεί η βιώσιμη ανάπτυξη εισέρχεται στην πολιτική αρένα, όπου τα συγκρουόμενα και αλληλένδετα συμφέροντα αγωνίζονται να επιβάλουν την δικιά τους ερμηνεία σε σχέση με τη βιωσιμότητα.

Η βιώσιμη ανάπτυξη ως ένας απώτερος στόχος πολιτικής άρχισε να εμφανίζεται σε διάφορα παγκόσμια «μεγάλα συνέδρια» μετά το 1987. Πρώτον, η Διάσκεψη των Ηνωμένων Εθνών για το Περιβάλλον και την Ανάπτυξη (UNCED) πραγματοποιήθηκε το 1992 στο Ρίο και αποτέλεσε την τρίτη "μεγάλη διάσκεψη" μετά τη Στοκχόλμη και το Ναϊρόμπι το 1982. Το αποτέλεσμα αυτής της διάσκεψης ήταν ότι η Διακήρυξη του Ρίο ήταν απλώς μια επανάληψη της συνεχούς συζήτησης που άρχισε ήδη στη Στοκχόλμη το 1972 και αυτή ήταν η σχέση μεταξύ Βορρά και Νότου. Καθώς αυτό δεν είναι το πεδίο εφαρμογής της διατριβής, δεν θα περιγραφεί λεπτομερέστερη επισκόπηση αυτού του θέματος. Έτσι, η Διακήρυξη του Ρίο σχεδίασε ένα σύνολο κατευθυντήριων αρχών βάσει των οποίων οι εθνικές κυβερνήσεις και οι διεθνείς οργανισμοί πρέπει να εφαρμόσουν τις περιβαλλοντικές πολιτικές τους. Υπάρχει, για παράδειγμα, μια επίκληση και τάση να υιοθετηθεί η αποκαλούμενη "αρχή" «ο ρυπαίνων πληρώνει» (polluter-pays-principle) καθώς και η «αρχή της πρόληψης» (precautionary principle). Επιπρόσθετα, υπογράμμισε την ανάγκη για αυξημένη δημοκρατική συμμετοχή και αξιολόγηση περιβαλλοντικών επιπτώσεων των αναπτυξιακών προγραμμάτων.

Δεύτερον, το 2002, περισσότεροι από 22.000 άνθρωποι παρακολούθησαν την Παγκόσμια Διάσκεψη των Ηνωμένων Εθνών για τη βιώσιμη ανάπτυξη (WSSD) στο Γιοχάνεσμπουργκ της Νότιας Αφρικής. Γενικά, η Διάσκεψη του Γιοχάνεσμπουργκ ήταν επίσης η απόδειξη ότι ο όρος «βιώσιμη ανάπτυξη» είχε αποκτήσει πολιτική αποδοχή. Παρόλο που κάποιοι ισχυρίστηκαν ότι ο όρος έχασε την αρχική του δυναμική και χρησιμοποιήθηκε κυρίως ρητορικά, το γεγονός παραμένει ότι υπογραμμίστηκε πολιτική ανάγκη της πρακτικής εφαρμογής της. Γενικά, το Γιοχάνεσμπουργκ θεωρήθηκε ως μια ευκαιρία να προωθηθεί η ατζέντα που είχε θέσει το Ρίο. τουλάχιστον, πρόσφερε την ευκαιρία να κρατήσει ζωντανή την ατζέντα του Ρίο.

Τρίτον, η διάσκεψη των Ηνωμένων Εθνών για την βιώσιμη ανάπτυξη (UNCSD), γνωστή και ως Rio 2012, Rio + 20 ή Earth Summit 2012 και ήταν το τρίτο διεθνές συνέδριο για την βιώσιμη ανάπτυξη με στόχο τον συνδυασμό των οικονομικών και περιβαλλοντικών στόχων της παγκόσμιας κοινότητας. Προϊόν του συνεδρίου ήταν η έκθεση "Το μέλλον που θέλουμε". Η έκθεση υποστηρίζει το σχεδιασμό στόχων βιώσιμης ανάπτυξης (Sustainable Development Goals- SDGs), ένα σύνολο μετρήσιμων στόχων που αποσκοπούν στη μέτρηση και υποστήριξη της βιώσιμης ανάπτυξης σε παγκόσμιο επίπεδο. Η αρχική σκέψη πίσω από τα SDG είναι ότι αυτά θα επιταχύνουν την εκπλήρωση των Αναπτυξιακών Στόχων της Χιλιετίας (Millenium Development Goals- MDGs). Κατά συνέπεια, μια τέτοια σκέψη στοχεύει στους επικριτές των MDGs, καθώς υποστήριζαν ότι αυτοί οι συγκεκριμένοι στόχοι απέτυχαν να αντιμετωπίσουν το ρόλο του περιβάλλοντος στην ανάπτυξη. Εκτός από αυτό, το Πρόγραμμα των Ηνωμένων Εθνών για το Περιβάλλον (UNEP) προωθείται ως η "ηγετική παγκόσμια περιβαλλοντική αρχή". Για το λόγο αυτό ορίζονται οκτώ βασικές συστάσεις, μεταξύ των οποίων είναι η ενίσχυση της διακυβέρνησής του μέσω της καθολικής συμμετοχής, η αύξηση των οικονομικών πόρων του και η ενδυνάμωση της συμμετοχής του σε βασικούς οργανισμούς συντονισμού των Ηνωμένων Εθνών.

Συνολικά, η βιώσιμη ανάπτυξη και η βιωσιμότητα ακολούθησαν μια πολύ ενδιαφέρουσα πορεία. Σύμφωνα με τις βασικές υποθέσεις, ο όρος συμπεριλήφθηκε ως πολιτική παράμετρος από τον 16ο αιώνα. Σε ορισμένες περιπτώσεις, όπως η δασοκομία, η βιωσιμότητα χαιρετίστηκε ως βασικός στόχος και όχι πάντα περιβαλλοντικός. Μετά τον Β’ Παγκόσμιο Πόλεμο, η έννοια αποκτά σταδιακά μεγαλύτερη σημασία λόγω της προβολής πολλών περιβαλλοντικών προβλημάτων που προκαλούνται από την ταχεία εκβιομηχάνιση. Τέλος, η βιώσιμη ανάπτυξη εισήλθε στο πεδίο της παγκόσμιας περιβαλλοντικής πολιτικής. Από το 1987, όπου η έννοια της βιώσιμης ανάπτυξης είχε επίσημα "γεννηθεί", η έννοια υπόκειται σε περαιτέρω ερμηνείες. Τέτοιες ερμηνείες οφειλόταν στην ασάφεια της έννοιας, αλλά ταυτόχρονα θεωρήθηκε ως μια αμφισβητούμενη έννοια και έπεσε «θύμα» της παγκόσμιας πολιτικής αρένας. Διάφοροι δρώντες μέρη, πολιτικοί, οργανώσεις και επιστημολογικές κοινότητες στοχεύουν στην προσαρμογή και τον καθορισμό της αειφόρου ανάπτυξης ανάλογα με τις ανάγκες τους Αυτό μπορεί να αποδειχθεί από τις δύο τελευταίες διασκέψεις το 2002 και το 2012. Μια προσεκτική εικόνα της πολιτικής για την βιώσιμη ανάπτυξη θεωρείται χρήσιμη για να επικυρώσει ή ίσως να αναδιατυπώσει την τροχιά της έννοιας της βιώσιμης ανάπτυξης. Ακόμη και αν η έννοια έχει χάσει τις αρχικές φιλοδοξίες και τη μοναδικότητα της, μπορεί ασφαλώς να διαδραματίσει σημαντικό ρόλο ως πιο επιχειρησιακό και ποσοτικοποιήσιμο στόχο, όπως οι SDG.

Η δυναμική αλληλεξάρτηση μεταξύ κοινωνικού, οικονομικού και βιολογικού συστήματος

Σε σχέση με τη δεύτερη φράση της διδακτορικής διατριβής, εκφράζεται η θεώρηση ότι αυτή ήταν απλώς μια εξειδίκευση του ορισμού της βιώσιμης ανάπτυξης. Παρ 'όλα αυτά, επελέγη μια εναλλακτική πορεία, έτσι ώστε να υπάρχει ένας αντίστοιχα εναλλακτικός ορισμός της βιώσιμης ανάπτυξης.

Κατά συνέπεια, το πρώτο ερώτημα που προέκυψε ήταν ποια ερμηνεία της βιώσιμης ανάπτυξης πρέπει να επιχειρήσει να αναλύσει αυτή η διδακτορική διατριβή. Επιπλέον, πώς εξηγείται αυτή η επιλογή; Ποιες είναι οι παράμετροι που κατευθύνουν την έρευνα σε αυτό; Από τη μία πλευρά, περιγράφηκε το θέμα της διαγενειακής δικαιοσύνης. Ερωτήσεις που σχετίζονται με τη δικαιοσύνη μεταξύ των γενεών είναι τι, πώς και πόσο πρέπει να διατηρήσουμε για την επόμενη γενιά; "Αν απαντηθούν αυτές οι ερωτήσεις τότε θα απαντηθεί επαρκώς η ερευνητική ερώτηση. Πιο συγκεκριμένα, το κύριο ερώτημα ήταν απλώς δεοντολογικό. Με άλλα λόγια, εάν η σημερινή γενιά κληρονομήσει κάτι στην επόμενη γενιά με ποιό τρόπο και πόσο; Αυτό το κεφάλαιο προσέφερε μια συνοπτική ανάλυση της βιωσιμότητας που εξετάστηκε από την οπτική της δικαιοσύνης μεταξύ γενεών.

Για το λόγο αυτό, η διδακτορική διατριβή επικεντρώθηκε επιστημονικό πεδίο της πολιτικής φιλοσοφίας που ασχολείται με αυτή τη επιστημονική συζήτηση από αιώνες. Από την πληθώρα των θεωριών που αφορούν της διαγενειακής δικαιοσύνης, η θεωρία του John Rawls (1971) επιλέχθηκε ως αυτή που θα μπορούσε να ταιριάζει με τα βασικά χαρακτηριστικά της βιωσιμότητας. Εκεί βασική του θέση ήταν το νοητικό πείραμα που ονόμασε «πρωταρχική θέση» (original position). Εκεί στα πλαίσια ενός υποθετικού σενάριο, μια ομάδα προσώπων ορίζει το καθήκον επίτευξης μιας συμφωνίας για την πολιτική και οικονομική δομή μιας κοινωνίας της οποίας θα αποτελέσουν μέλη, άπαξ επιτευχθεί η εν λόγω συμφωνία. Κάθε άτομο, όμως, διαπραγματεύεται πίσω από ένα «πέπλο άγνοιας» (veil of ignorance), έχοντας άγνοια σχεδόν για ο,τιδήποτε αφορά αυτόν και τους άλλους συμμετέχοντες (Rawls, 1971). Οι συμμετέχοντες της αρχικής θέσης προσαρμόζουν τη συμπεριφορά τους σε ορισμένες βασικές αρχές της δικαιοσύνης, οι οποίες, σύμφωνα με τους Rawls, είναι οι πρωταρχικοί κανόνες που συνιστούν την «έννοια της δικαιοσύνης» (justice as fairness). Αυτές οι αρχές είναι οι ακόλουθες (Rawls, 2001):

- Η αρχή της «ίσης ελευθερίας»: «κάθε πρόσωπο έχει την ίδια αδικαιολόγητη απαίτηση για ένα πλήρως επαρκές σύστημα ίσων βασικών ελευθεριών, το οποίο σύστημα είναι συμβατό με το ίδιο σύστημα ελευθεριών για όλους»,
- Η δεύτερη αρχή περιλαμβάνει τις ακόλουθες δύο υπο-αρχές
    - την αρχή των «ανοικτών γραφείων» (open offices principle): «οι κοινωνικές και οικονομικές ανισότητες πρέπει να συνδέονται με γραφεία και θέσεις ανοικτές σε όλους υπό συνθήκες δίκαιης ισότητας ευκαιριών», ο
    - την αρχή της διαφοράς (difference principle): «οι κοινωνικές και οικονομικές ανισότητες πρέπει να είναι προς όφελος των λιγότερο ευνοημένων μελών της κοινωνίας».

Αργότερα, ο Rawls σκόπευε να ενσωματώσει μια επιπλέον αρχή στη θεωρία της δικαιοσύνης. Ως εκ τούτου, πρότεινε μια «αρχή των αναγκών» που θα είναι λεξολογική (lexical) πριν από τις άλλες αρχές (Rawls, 1993). Αυτή η προσθήκη υπογραμμίζει την ανάγκη να παρέχεται επαρκές ελάχιστο όριο στους ανθρώπους, προτού να καλυφθούν όλες οι άλλες αρχές της δικαιοσύνης και, ως εκ τούτου, η θεωρία της δικαιοσύνης μπορεί να χαρακτηριστεί ως «μέτρια επαρκιστική» - “moderate sufficientary” (Wolf, 2009). Θα πρέπει να υπογραμμιστεί ότι η τοποθέτηση της θεωρίας της δικαιοσύνης σε μια συγκεκριμένη κατηγορία δεν έχει άμεσο αποτέλεσμα. Υπάρχει ήδη η "αρχή της διαφοράς" που εξ ορισμού έχει μια λεγόμενη επαρκιστική έννοια. Ωστόσο, η παρατήρηση της ιεραρχίας των αρχών φαίνεται να παρουσιάζει ιδιαίτερο ενδιαφέρον. Μια "αρχή των αναγκών" μπορεί να ικανοποιηθεί πλήρως ακόμη και με την ύπαρξη τεράστιων ανισοτήτων, ενώ η "αρχή διαφοράς" θα συνεχίσει να δημιουργεί απαιτήσεις ακόμα και όταν ικανοποιούνται όλες οι ανάγκες. Εάν μια "αρχή των αναγκών" απαιτεί την ελαχιστοποίηση της ανεκπλήρωτης ανάγκης, τότε η αρχή των αναγκών θα δημιουργήσει περιστασιακά απαιτήσεις που δεν συνάδουν με την αρχή της διαφοράς (Wolf, 2009).

Με βάση τα παραπάνω, παρατηρήθηκε ότι η θεωρία του Rawls δεν μπορούσε να υιοθετηθεί άμεσα, πριν εφαρμοστούν ορισμένες τροποποιήσεις. Αυτός είναι ο λόγος για τον οποίο επιχειρήθηκε μια "μεταστρουκτουραλιστική" προσαρμογή. Με τον τρόπο αυτό, η θεωρία τροποποιήθηκε κατά τρόπο ώστε το τελικό της προϊόν συνέπεσε με τη θέση του Gosseries ότι η βιωσιμότητα μπορεί να θεωρηθεί επαρκιστική έννοια, δηλαδή "επαρκισμός του Brundtland" (“Brundtland’s sufficientarism”) (Gosseries, 2011). Και πάλι παρατηρήθηκαν κάποιες λανθασμένες υποθέσεις σχετικά με τον ορισμό της βιωσιμότητας. Ωστόσο, όπως προαναφέρθηκε, αυτό είναι ο «λόγος ύπαρξης» αυτής της διατριβής και με βάση αυτό, η προσπάθεια της έρευνας στοχεύει να διερευνήσει περαιτέρω την αλληλεξάρτηση μεταξύ διαγενειακής δικαιοσύνης και βιωσιμότητας.

Από την άλλη, παρουσιάστηκε το θέμα της δικαιοσύνης εντός γενεών, η ενδογενεακή δικαιοσύνη. Κρίσιμο ζήτημα θεωρήθηκε η ικανοποίηση των ανθρώπινων βασικών αναγκών. Κατά συνέπεια, το ερώτημα θα μπορούσε να συνοψιστεί ως εξής: τι θεωρούν τα ανθρώπινα όντα ως σημαντικό για τη δική τους ευημερία, που είναι επομένως ζωτικής σημασίας για τη διατήρηση και κληρονομιά των επόμενων γενεών; Επιπλέον, ένα άλλο ερώτημα ήταν αν υπάρχουν συγκεκριμένες ανάγκες που πρέπει να ικανοποιηθούν προκειμένου ένα άτομο να επιτύχει ένα ορισμένο «κατώφλι»- ελάχιστο επίπεδο ευημερίας. Επιπλέον, η επόμενη ερώτηση που προέκυψε ήταν ο τρόπος με τον οποίο θα μπορούσε να καθοριστεί αυτό το όριο για αυτό το άτομο. Υπάρχουν θεωρίες που καθορίζουν τις βασικές ανάγκες ενός ανθρώπου;

Το κεφάλαιο ξεκίνησε με μια λεπτομερή περιγραφή της προσέγγισης του Amartya Sen, που είναι γνωστή ως η «Προσέγγιση των Δυνατοτήτων»- “Capability Approach”. Το κανονιστικό πλαίσιο του Sen αποτελείται από δύο βασικά χαρακτηριστικά. Αυτά είναι τα εξής (Sen, 1999):

- Οι λειτουργίες (functionings) είναι καταστάσεις "ύπαρξης και πράξης", όπως η καλή διατροφή, η κατοχή καταφυγίου. Θα πρέπει να διακρίνεται από τα εμπορεύματα που χρησιμοποιούνται για την επίτευξή τους (όπως το "ποδήλατο" διακρίνεται από το "που διαθέτει ποδήλατο").

- Δυνατότητα ή δυνατότητες (capabilities) αναφέρονται στη σειρά των πολύτιμων λειτουργιών στις οποίες έχει πρόσβαση κάποιος. Έτσι, η ικανότητα ενός ατόμου αντιπροσωπεύει την πραγματική ελευθερία ενός ατόμου να επιλέξει μεταξύ διαφορετικών λειτουργικών συνδυασμών - ανάμεσα σε διαφορετικά είδη ζωής - που έχει λόγο να εκτιμήσει.

Κατά συνέπεια, αυτό που έχει σημασία για τον Sen είναι αυτό που οι άνθρωποι είναι πραγματικά ικανοί να είναι και να κάνουν. Τα αγαθά, τα μέσα, οι πλούσιοι άνθρωποι έχουν στη διάθεσή τους ή τη χρησιμότητά τους που αποκτούν από αυτά τα "μέσα" (π.χ. ευτυχία) δεν επαρκούν καθώς περιορίζουν την ολιστική μας προοπτική. Για το λόγο αυτό, ο Sen χρησιμοποιεί ένα πολύ χαρακτηριστικό παράδειγμα, αυτό του ποδηλάτου. Έχοντας ένα ποδήλατο (πόρος εισροής) δεν αρκεί για την επίτευξη ενός ορισμένου επιπέδου ευημερίας, καθώς αυτό εξαρτάται από άλλους παράγοντες. Επομένως, η αξία του κάθε ποδηλάτου εξαρτάται από την ικανότητά του να μετατρέπει τα άτομα σε λειτουργία, η οποία εξαρτάται επίσης από την προσωπική τους κατάσταση και φυσική κατάσταση (φυσιολογία), τους κοινωνικούς κανόνες και το φυσικό περιβάλλον (Sen, 1999).

Πέρα από αυτές τις δύο κατηγορίες υπάρχουν και τρεις ομάδες από παράγοντες μετατροπής, προσωπικοί, κοινωνικοί και περιβαλλοντικοί, οι οποίοι μπορούν να μετατρέψουν τις δυνατότητες σε λειτουργίες (Robeyns, 2011).

Παρόμοια με αυτή την προσέγγιση παρουσιάστηκε επίσης η προσέγγιση της Martha Nussbaum σχετικά με τις βασικές ανάγκες, καθώς και οι δύο επιστήμονες ξεκίνησαν την ανάλυση αυτής της προσέγγισης από κοινού. Ωστόσο, η Nussbaum επέλεξε μια πιο αποφασιστική ανάλυση των βασικών αναγκών. Πιο συγκεκριμένα η «Προσέγγιση της Ανθρώπινης Ανάπτυξης» ("Human Development Approach") διατηρώντας το κεντρικό νόημα των λειτουργιών, χωρίς να το μεταβάλει, ορίζει σαφώς τις βασικές δυνατότητες. Στόχος της είναι να επικεντρωθεί στην προστασία των χώρων ελευθερίας τόσο κεντρικά ώστε η μη ικανοποίηση τους να κάνει μια ζωή που δεν αξίζει ανθρώπινης αξιοπρέπειας (Nussbaum, 2011: σελ.31). Τέλος, η Nussbaum παρουσιάζει τον κατάλογο των δέκα κεντρικών δυνατοτήτων της, όπου μια αξιοπρεπής πολιτική τάξη πρέπει να εξασφαλίζει σε όλους τους πολίτες τουλάχιστον ένα κατώτατο όριο (Nussbaum, 2011: σελ.33)

- Ζωή
- Φυσική Υγεία
- Ακεραιότητα του σώματος
- Αίσθηση, Φαντασία και Σκέψη
- Συναισθήματα
- Πρακτικός λόγος
- Συνεργασία
- Άλλα είδη
- Παιχνίδι
- Έλεγχος του περιβάλλοντος του ατόμου

Επιπλέον, παρουσιάστηκε η προσέγγιση του Max Neef σχετικά με τις βασικές ανάγκες (Neef et al., 1989). Σε αντίθεση με τους άλλους δύο, ο Max Neef ενδιαφέρεται να παρουσιάσει μια πολύ λεπτομερή και πλήρη λίστα βασικών αναγκών που ικανοποιούν την ευημερία ενός ατόμου. Το κεφάλαιο ολοκληρώνεται παρουσιάζοντας τρεις προσεγγίσεις που προσπαθούν να συγχωνεύσουν στοιχεία και των τριών προσεγγίσεων ενώ προσπαθούν να ενσωματώσουν τη βιωσιμότητα ρητά ή σιωπηρά.

Πέρα από αυτές τις βασικές προσεγγίσεις αναφορικά με ενδογενειακή δικαιοσύνη, υπάρχουν προσεγγίσεις που προσπαθούν να ενσωματώσουν σε αυτές τον παράγοντα και τη διάσταση του φυσικού περιβάλλοντος. Οι Felix Rauschmayer (2011) και Ortrud Leßmann (2011) προσπαθούν να ενσωματώσουν ρητά τη βιωσιμότητα. Ενώ η Rauschmayer επιχειρεί να ενσωματώσει την έννοια του Max Neef με την έννοια της βιωσιμότητας, οι προσπάθειες της Leßmann επικεντρώνονται στη συγχώνευση της βιωσιμότητας με το Capability Approach. Η έννοια «μέσο» (agency) διαδραματίζει τον βασικό ρόλο στην ανάλυσή του και εξασφαλίζει την αρμονική συνύπαρξη δύο εννοιών με διαφορετικά χαρακτηριστικά. Ωστόσο, απαιτείται περισσότερη επεξεργασία και για τις δύο προσεγγίσεις.

Η Breena Holland (2014) προσπαθεί να προσφέρει μια πιο συγκεκριμένη προσέγγιση σχετικά με το πώς μπορεί να ενσωματωθεί το περιβάλλον στην εξίσωση της ευημερίας. Εδώ η βιωσιμότητα υπονοείται και αρχικά ορίζεται ως "οικολογική μετα-ικανότητα". Επιπλέον, ορίζονται τα "όρια και ανώτατα όρια δυνατοτήτων". Τα κατώφλια ικανότητας αναφέρονται στο ελάχιστο επίπεδο που πρέπει να διασφαλίζονται οι βασικές δυνατότητες ενός ατόμου, ενώ τα ανώτατα όρια ικανότητας αναφέρονται στα μέγιστα επίπεδα βασικών δυνατοτήτων που επιτρέπεται σε ένα άτομο να επιτύχει. Αν ξεπεραστούν αυτά τα ανώτατα όρια, αυτό μπορεί να οδηγήσει στο να θιχτούν οι βασικές δυνατότητες του άλλου ατόμου. Αυτά τα ανώτατα όρια συσχετίζονται άμεσα και καθορίζονται από οικολογικά όρια. Αυτή η παρατήρηση υπονοεί τη βιωσιμότητα που μοιράζεται το ίδιο χαρακτηριστικό. Σίγουρα, η Holland προσπαθεί να παράσχει μια πιο πρακτική περιγραφή του τρόπου με τον οποίο μπορούν να διασφαλιστούν οι βασικές δυνατότητες, εξασφαλίζοντας ένα βιώσιμο περιβάλλον. Παρ 'όλα αυτά, η προσπάθειά της επικεντρώνεται στην ατομική ευημερία. Δεδομένου ότι το πλαίσιο της είναι σχολαστικά σχεδιασμένο, η προσπάθειά της μπορεί να χρησιμεύσει ως ένα χρήσιμο θεωρητικό υπόβαθρο, το οποίο μπορεί να επεκταθεί ώστε να περιλαμβάνει ρητά τη βιωσιμότητα. Εδώ ο ρόλος του «μέσου» μπορεί να παρέχει τον απαραίτητο σύνδεσμο έτσι ώστε να μπορεί να αναπτυχθεί η προσέγγιση της.

Μετά την ανάλυση της έννοιας της βιωσιμότητας και την εξέταση της έννοιας της ευημερίας, η ανάλυση στοχεύει να επικεντρωθεί σε έννοιες και μετρήσεις που σχετίζονται άμεσα ή έμμεσα με τη βιώσιμη ανάπτυξη. Υπάρχει μια τέτοια μέτρηση; Πώς εκφράζεται η βιωσιμότητα στο πλαίσιο αυτό και πώς αξιολογείται η ευημερία;

Εδώ το πλαίσιο των οικοσυστημικών υπηρεσιών (Ecosystem Services- ES) έχει προσδιοριστεί ως ο πρωταρχικός υποψήφιος. Εκτός αυτού, θα πρέπει να εξεταστεί ο τρόπος ενσωμάτωσης της βιωσιμότητας στο πλαίσιο των οικοσυστημικών υπηρεσιών. Αυτό βασικά είναι κρυπτογραφημένο με τον τρόπο κατηγοριοποίησης των ES.

Οι υπηρεσίες που προσφέρουν τα οικοσυστήματα, οι οικοσυστημικές υπηρεσίες, ορίζονται από την ευημερία που ο άνθρωπος αποκομίζει από τα οικοσυστήματα (MA, 2005).

Η πρώτη προσπάθεια συστηματοποίησης αυτών των υπηρεσιών σε παγκόσμιο επίπεδο έγινε με το Millennium Ecosystem Assessment (MA) το 2005 (MA, 2005). Το Πρόγραμμα αυτό, υπό την αιγίδα του Ο.Η.Ε. και άλλων φορέων, όπως το IPCC, η Παγκόσμια Τράπεζα και ο Παγκόσμιος Οργανισμός Τροφίμων είχε ως στόχο να αποτιμήσει τις επιπτώσεις των αλλαγών των οικοσυστημάτων στην ανθρώπινη ευημερία (MA, 2005).

Βάσει του ΜΑ, οι οικοσυστημικές υπηρεσίες ταξινομήθηκαν σε (MA, 2005):

- Τροφοδοτικές υπηρεσίες (provisioning services) που αφορούν την παροχή αγαθών από τα οικοσυστήματα
- Ρυθμιστικές υπηρεσίες (regulating services) που αφορούν τη λειτουργία των διαδικασιών του οικοσυστήματος καθώς και του οικοσυστήματος και της βιόσφαιρας γενικότερα
- Υποστηρικτικές υπηρεσίες (supporting services), υπηρεσίες απαραίτητες για την εύρυθμη λειτουργία όλων των υπόλοιπων υπηρεσιών
- Τις πολιτιστικές υπηρεσίες (cultural services), που αφορούν τα η υλικά οφέλη που αποκομίζει ο άνθρωπος από τα οικοσυστήματα.

Πέραν του Millenium Assessment (MA, 2005), άλλα πλαίσια ανάλυσης των οικοσυστημικών υπηρεσιών περιορίζονται σε τρεις βασικές κατηγορίες για τις οικοσυστημικές υπηρεσίες, συγχωνεύοντας τις ρυθμιστικές και τις υποστηρικτικές υπηρεσίες (Kumar, 2009). Εάν εξεταστούν προσεκτικά, θα μπορούσε κανείς να βρει μια άμεση ερμηνεία των τριών πυλώνων της βιωσιμότητας. Αυτό σημαίνει ότι οι ρυθμιστικές υπηρεσίες αντιστοιχούν στην οικολογική βιωσιμότητα, οι τροφοδοτικές υπηρεσίες παρέχουν υπηρεσίες οικονομικής βιωσιμότητας και, τέλος, οι πολιτιστικές υπηρεσίες στην κοινωνική βιωσιμότητα (Grunewald και Bastian, 2015). Επομένως, εκτιμώντας τις διάφορες κατηγορίες των οικοσυστημικών υπηρεσιών, μπορεί επίσης να εκτιμηθεί η κατάσταση της βιωσιμότητας εν μέρει ή στο σύνολό της.

Δύο συγκεκριμένα χαρακτηριστικά του πλαισίου των οικοσυστημικών υπηρεσιών μπορούν να θεωρηθούν ως ανεκτίμητη προσθήκη και ερμηνεία της ευημερίας και της βιωσιμότητας. Από τη μία πλευρά, η ευημερία είναι άμεσα πλαισιωμένη ως πρωταρχικός στόχος του πλαισίου των οικοσυστημικών υπηρεσιών. Από την άλλη πλευρά, η επίτευξη της ευημερίας επιτυγχάνεται με τη μέτρηση της κατάστασης των οικοσυστημάτων. Συνεπώς, η ευημερία είναι άμεσα συσχετισμένη με το περιβάλλον και την τρέχουσα και μελλοντική του κατάσταση. Οι προσεγγίσεις της ES έχουν δανειστεί από τις προαναφερθείσες θεωρίες και έννοιες όπως αυτή των Sen (1999) και Nussbaum (2011). Παρ 'όλα αυτά, το κέντρο της προσοχής είναι διττό. Πρώτον, η προσοχή εστιάστηκε στην ανθρώπινη ευημερία μέσω της βοήθειας των οικοσυστημικών υπηρεσιών, ως ροές υπηρεσιών που μεταφράζονται ως οφέλη για τον άνθρωπο. Δεύτερον, το περιβάλλον πρέπει να θεωρείται ως το περιβάλλον, δηλαδή ο "οίκος" των ανθρώπων, επομένως η ευημερία είναι εξαρτώμενη από την κατάσταση του περιβάλλοντος (αποθέματα) και την προσφορά (ροή).

Επιπλέον, το πλαίσιο των οικοσυστημικών υπηρεσιών παρουσιάζει ένα ενδιαφέρον χαρακτηριστικό που έχει αναφερθεί και πάλι παραπάνω. Αυτό είναι το χαρακτηριστικό της "δυναμικής", το οποίο θεωρείται εδώ ως η δυναμική ενός οικοσυστήματος για την παροχή των οικοσυστημικών υπηρεσιών. Αυτός είναι ο ίδιος μηχανισμός που βρίσκεται πίσω από το πλαίσιο του Sen (1999) που εξετάζει τις δυνατότητες, δηλαδή τι μπορεί να επιτύχει ένα άτομο, σε αντίθεση με τις λειτουργίες. Αυτή η έννοια μεταφέρεται στο οικοσύστημα στο πλαίσιο των οικοσυστημικών υπηρεσιών, υπογραμμίζοντας την ανάγκη να επικεντρωθεί στη δυναμική, δηλαδή τι μπορεί να προσφέρει ένα οικοσύστημα, καθώς σε πολλές περιπτώσεις το οικοσύστημα μπορεί να προσφέρει αυτές τις δυνητικές υπηρεσίες στο μέλλον ή / και να προσφέρει ένα αυξημένο / μειωμένο επίπεδο των υφιστάμενων υπηρεσιών.

Συνολικά, είναι εμφανές ότι οι οικοσυστημικές υπηρεσίες μπορούν να αποτελέσουν ένα κοινό τόπο όπου η έννοια της ευημερίας μαζί με την έννοια της βιωσιμότητας μπορούν να ενσωματωθούν με επιτυχία. Συνεπώς, ο στόχος του επόμενου κεφαλαίου είναι να διατυπώσει αυτές τις θεωρητικές επιπτώσεις σε ένα πρακτικό παράδειγμα.

Παραδείγματα από την Ευρώπη και τις ΗΠΑ

Το τελευταίο στάδιο της ερευνητικής διαδικασίας ήταν η πρακτική εφαρμογή του πλαισίου των οικοσυστημικών υπηρεσιών ή ακόμη και άλλες έννοιες που επικεντρώνονται στη βιωσιμότητα. Το πρώτο ερώτημα ήταν αν μπορεί να υπάρξει ένα παράδειγμα περί του τρόπου αξιολόγησης των οικοσυστημικών υπηρεσιών και αξιολόγησης της αξίας τους. Επιπλέον, ένα άλλο θέμα του κεφαλαίου ήταν βασικά πώς μπορούν να εφαρμοστούν στην πράξη οι υπηρεσίες οικοσυστήματος, πώς θα μπορούσαν οι υφιστάμενες έννοιες και πολιτικές να συμβάλλουν στη διαμόρφωση της αξίας των υπηρεσιών οικοσυστήματος και πώς θα μπορούσε να χρησιμοποιηθεί περαιτέρω για τη χάραξη πολιτικής.

Το κεφάλαιο αυτό αφορούσε την εκτίμηση της αξίας των υπηρεσιών οικοσυστήματος σε συγκεκριμένες γεωγραφικές περιοχές. Ειδικότερα, εκτιμήθηκε η αξία τριών υπηρεσιών οικοσυστήματος. Αυτά ήταν τα εξής:

- Παροχή τροφοδοτικής υπηρεσίας (παροχή πόσιμου νερού)
- Παροχή τροφοδοτικής υπηρεσίας (παροχή αρδευτικού νερού)
- Παροχή τροφοδοτικής υπηρεσίας (νερό για παραγωγή ηλεκτρικής ενέργειας)

Τα Σχέδια Διαχείρισης Λεκανών Απορροής των υδάτινων διαμερισμάτων (ΥΔ) της Κεντρικής και Δυτικής Μακεδονίας (Ειδική Γραμματεία Υδάτων, 2014α; 2014b) ήταν η κύρια πηγή για τον υπολογισμό της αξίας και των τριών υπηρεσιών. Η μεθοδολογία που χρησιμοποιήθηκε και στα δύο Σχέδια Διαχείρισης χρησιμοποιήθηκε για την εκτίμηση των τριών υπηρεσιών παροχής.

Η παροχή πόσιμου ύδατος και η χρήση ύδατος για γεωργική χρήση αντιμετωπίστηκαν από κοινού, καθώς θεωρήθηκαν ως ανταγωνιστικές και σημαντικές χρήσεις σε αμφότερα τα Υ.Δ.. Στις περιπτώσεις αυτές, υπολογίστηκε το οικονομικό κόστος, το περιβαλλοντικό κόστος και το κόστος πόρου και συνεπώς θεωρήθηκε ότι ισούται με τη συνολική αξία και των δύο οικοσυστημικών υπηρεσιών.

Εκτός αυτού χρησιμοποιήθηκε μια ελαφρώς διαφορετική προσέγγιση για τη χρήση νερού για παραγωγή ηλεκτρικής ενέργειας. Κυρίως, υπολογίστηκε το κόστος των οικονομικών πόρων και των πόρων των μεγάλων υδροηλεκτρικών σταθμών (ΜΥΗΣ). Ωστόσο, τα οφέλη που απορρέουν από τη χρήση μεγάλων υδροηλεκτρικών σταθμών υπολογίστηκαν επιπρόσθετα και η αξία αυτών των οφελών θα μπορούσε να αντανακλά καλύτερα την αξία του νερού για τη χρήση ηλεκτρικής ενέργειας. Αυτές οι θετικές εξωτερικές επιπτώσεις περιλαμβάνουν την παραγωγή ηλεκτρικής ενέργειας με τη χρήση πηγών ενέργειας που παράγουν εκπομπές CO_2. Οι μεγάλες υδροηλεκτρικές μονάδες δεν παράγουν εκπομπές CO_2. Τέτοιες εκπομπές είναι επιβλαβείς για το περιβάλλον και συμβάλλουν στην αλλαγή του κλίματος. Κατά συνέπεια, η μεγάλη υδροηλεκτρική παραγωγή έχει ένα σιωπηρό περιβαλλοντικό όφελος που πρέπει να εκτιμηθεί και να ληφθεί υπόψη.

Η έννοια που διατυπώθηκε από τους Koundouri et al. (2016) αποτέλεσαν τη θεωρητική βάση για την ανάλυση και την εκτίμηση της αξίας των υπηρεσιών οικοσυστήματος, ειδικά για τις δύο πρώτες υπηρεσίες παροχής. Με βάση τα ανωτέρω, θεωρήθηκε ότι η αξία των υπηρεσιών παροχής υπηρεσιών για την παροχή γλυκού νερού και την παροχή γεωργικού νερού θεωρείται ότι ισούται με τη συνολική αξία / κόστος του νερού όπως εκτιμήθηκε στα σχέδια διαχείρισης λεκάνης απορροής ποταμών. Παρ 'όλα αυτά, υπήρξε μια σοβαρή απόκλιση από τη μεθοδολογία που πρότεινε ο Koundouri et al. (2016), δεδομένου ότι η οικονομική αξιολόγηση των δυνητικών μέτρων για τη βιώσιμη διαχείριση των υδάτων εσκεμμένα δεν ελήφθη υπόψη.

Θα πρέπει να σημειωθεί ότι ο συγγραφέας ήταν μέλος της ερευνητικής ομάδας που ήταν υπεύθυνη για την οικονομική ανάλυση των χρήσεων ύδατος, η οποία ήταν μέρος των Ολοκληρωμένων Σχεδίων Διαχείρισης Λεκάνης Απορροής Ποταμών για αμφότερα τα ΥΔ (Ειδική Γραμματεία Υδάτων, 2014e; 2014f). Κύρια ερευνητική δραστηριότητα ήταν η εκτίμηση του λόγου ανάκτησης κόστους για τις σημαντικότερες χρήσεις νερού στα ΥΔ. Με βάση τη μεθοδολογία που πρότεινε η WATECO (2002), πρέπει να υπολογιστεί όχι μόνο το χρηματοοικονομικό κόστος. Τόσο το περιβαλλοντικό κόστος όσο και το κόστος των πόρων είναι κρίσιμες κατηγορίες κόστους που πρέπει να εκτιμηθούν και μπορούν να ορίσουν τη λεγόμενη Συνολική Οικονομική Αξία του Νερού (Kumar et al., 2009).

Μετά από εκτεταμένες συζητήσεις με τους ενδιαφερόμενους και τους εμπειρογνώμονες στον τομέα αυτό, καθορίστηκε η μεθοδολογία βάσει της οποίας εκτιμήθηκαν και οι τρεις κατηγορίες κόστους. Εάν εξετάσουμε προσεκτικά τη μεθοδολογία υπολογισμού του περιβαλλοντικού κόστους και για τις δύο υπηρεσίες παροχής υπηρεσιών, μπορούμε να σημειώσουμε ότι τα μελλοντικά έργα που εξασφαλίζουν τη βιώσιμη διαχείριση των υδάτων και στις δύο ΥΔ περιλαμβάνονται στον υπολογισμό του περιβαλλοντικού κόστους. Τέτοια έργα συμπεριλήφθηκαν επίσης στα σχέδια διαχείρισης λεκάνης απορροής ποταμών (Ειδική Γραμματεία Υδάτων, 2014e; 2014f). Με άλλα λόγια, το περιβαλλοντικό κόστος ήταν ιδιαίτερα στην περίπτωση της παροχής πόσιμου νερού που αντιστοιχεί στην υλοποίηση μελλοντικών έργων που συνδέονται άμεσα με τη βιώσιμη διαχείριση των υδάτων.

Ο υπολογισμός του κόστους πόρου υπολογίζεται αντιστοίχως και αναφέρεται σε απολεσθέντα οφέλη που οφείλονται κυρίως στην υπερβολική εκμετάλλευση υπογείων υδάτων, δημιουργώντας έτσι ένα επιπλέον κόστος που θα επιβαρύνει τους χρήστες νερού στο μέλλον, λόγω της αναμενόμενης έλλειψης αποθεμάτων ύδατος για την ικανοποίηση των αναγκών καθώς και τη ζήτηση όλων των χρήσεων νερού. Η προσέγγιση που χρησιμοποιείται για τη χρήση οδηγεί σε μια συντηρητική εκτίμηση αυτού του μελλοντικού κόστους και θα μπορούσε επίσης έμμεσα να θεωρηθεί ως κρυφό κόστος το οποίο θα πρέπει να κατανεμηθεί στις αντίστοιχες χρήσεις ύδατος και να οδηγήσει τις χρήσεις ύδατος στην προσαρμογή σε μια πιο βιώσιμη προσέγγιση διαχείρισης ύδατος (Bithas et al., 2014).

Κατά συνέπεια, τα πιθανά μέτρα για την βιώσιμη διαχείριση των υδάτων, όπως ορίζεται στο Koundouri et al. (2016) έχουν ήδη συμπεριληφθεί στην εκτίμηση της αξίας του νερού και στα δύο ΥΔ. Ως εκ τούτου, δεν υπήρξε ανάγκη να προστεθούν τα μέτρα αυτά, δεδομένου ότι τόσο η εκτίμηση του περιβαλλοντικού κόστους όσο και του κόστους των πόρων έλαβε υπόψη τα μελλοντικά έργα και τα μέτρα με τα οποία μπορεί να επιτευχθεί η βιώσιμη διαχείριση των υδάτινων πόρων στις λεκάνες απορροής των ΥΔ. Με άλλα λόγια, η διαφορά μεταξύ της αρχικής και της επιθυμητής κατάστασης των υδάτων, όπως διατυπώθηκε στην Οδηγία Πλαίσιο για τα Ύδατα, ενσωματώθηκε στη συνολική οικονομική αξία του νερού. Θεωρητικά, η συσσώρευση δυνητικών μέτρων και έργων στην ήδη πραγματοποιηθείσα οικονομική ανάλυση θα μπορούσε να θεωρηθεί ως "διπλή μέτρηση" (double counting). Πρόκειται για μια σοβαρή αλλά δυστυχώς συνήθη παγίδα στην εκτίμηση της αξίας των περιβαλλοντικών αγαθών όπως το νερό και πρέπει να αποφευχθεί (Kumar et al., 2009). Στην περίπτωση της οικονομικής ανάλυσης στα ΥΔ, αυτή η "διπλή μέτρηση" δεν έγινε, αλλά ήταν σημαντικό να δικαιολογηθεί σαφώς και επαρκώς η παράλειψη αυτού του υπολογισμού και η απόκλιση του μεθοδολογικού πλαισίου που πρότεινε ο Koundouri et al. (2016).

Τα αποτελέσματα σχετικά με τις δύο πρώτες οικοσυστημικές υπηρεσίες στα ΥΔ09 και ΥΔ10 παρουσιάζονται στους παρακάτω Πίνακες I-IV.

Πίνακας I:Εκτίμηση κόστους τροφοδοτικής υπηρεσίας (παροχή πόσιμου νερού) στο ΥΔ10. Πηγή: : Ειδική Γραμματεία Υδάτων, 2014α.

Κατηγορίες Κόστους	Αξιός	Γαλλικός	Χαλκιδική	Άθως	Συνολικό ΥΔ10
Χρηματοοικονομικό κόστος (Παροχή νερού)	19,611,330 €	8,055,555 €	79,190,082 €	885,704 €	107,742,671 €
Χρηματοοικονομικό κόστος (Βιομηχανία)		7,231,586 €			7,231,586 €
Περιβαλλοντικό Κόστος (Παροχή νερού)	3,971,524 €	1,297,069 €	13,427,716 €	- €	18,696,309 €
Περιβαλλοντικό Κόστος (Βιομηχανία)	776,725 €	532,959 €	476,513 €	- €	1,786,197 €
Κόστος Πόρου (Παροχή νερού)	606,422 €	150,699 €	820,009 €	- €	1,577,130 €
Κόστος Πόρου					

(Βιομηχανία)	331,268 €	542,428 €	112,857 €	- €	986,554 €
Σύνολο	**25,297,269 €**	**17,810,296 €**	**94,027,177 €**	**885,704 €**	**138,020,447 €**

Πίνακας ΙΙ: Εκτίμηση κόστους τροφοδοτικής υπηρεσίας (παροχή αρδευτικού νερού) στο ΥΔ10. Πηγή: : Ειδική Γραμματεία Υδάτων, 2014α.

Κατηγορίες Κόστους	Αξιός €	Γαλλικός	Χαλκιδική	Άθως	Συνολικό ΥΔ10
Χρηματοοικονομικό κόστος (Οργανωμένη άρδευση)	28,788,494 €	243,841 €	109,038 €	- €	29,141,373 €
Περιβαλλοντικό Κόστος (Organised Irrigation)	1,177,248 €	17,732 €	14,443 €	- €	1,209,423 €
Περιβαλλοντικό Κόστος (κτηνοτροφία)	269,122 €	65,302 €	340,100 €	- €	674,524 €
Περιβαλλοντικό Κόστος (Ιδιωτική άρδευση)	374,768 €	32,397 €	187,255 €	- €	594,420 €
Κόστος Πόρου (Οργανωμένη άρδευση)	63,659 €	14,869 €	70,977 €	- €	149,506 €
Κόστος Πόρου (Ιδιωτική άρδευση)	6,302,276 €	1,472,038 €	7,026,770 €	- €	14,801,084 €
Κόστος Πόρου (Stabled Livestock)	50,615 €	39,660 €	26,678 €	- €	116,953 €
Σύνολο	**37,026,182 €**	**1,885,839 €**	**7,775,261 €**	**- €**	**46,687,283 €**

Πίνακας ΙΙΙ: Εκτίμηση κόστους τροφοδοτικής υπηρεσίας (παροχή πόσιμου νερού) στο ΥΔ09. Πηγή: : Ειδική Γραμματεία Υδάτων, 2014β.

Κατηγορίες Κόστους	Αλιάκμονας	Πρέσπες	Υπολεκάνη Πρεσπών	Σύνολο ΥΔ09
Χρηματοοικονομικό κόστος (Παροχή νερού	51,745,540 €	2,473,450 €	80,944 €	54,218,990 €
Περιβαλλοντικό Κόστος (Περιβαλλοντικό Κόστος	12,902,829 €	886,238 €	- €	13,789,066 €
Περιβαλλοντικό Κόστος (Βιομηχανία)	1,109,013 €	6,845 €	- €	1,115,858 €
Κόστος Πόρου (Παροχή νερού)	985,297 €	-€	-€	985,297 €
Κόστος Πόρου (Βιομηχανία)	1,088,644 €	-€	-€	1,088,644 €
Σύνολο	67,831,323 €	3,366,533 €	80,944 €	71,197,855 €

Πίνακας IV: Εκτίμηση κόστους τροφοδοτικής υπηρεσίας (παροχή αρδευτικού νερού) στο ΥΔ 09. Πηγή: : Ειδική Γραμματεία Υδάτων, 2014β.

Κατηγορίες Κόστους	Αλιάκμονας	Πρέσπες	Υπολεκάνη Πρεσπών	Σύνολο ΥΔ09
Χρηματοοικονομικό κόστος (Οργανωμένη άρδευση)	9,193,335 €	276,365 €	211,970 €	9,469,701 €
Περιβαλλοντικό Κόστος (Οργανωμένη άρδευση)	441,844 €	82,159 €	24,640 €	524,003 €
Περιβαλλοντικό Κόστος (κτηνοτροφία)	709,054 €	112,906 €	14,678 €	821,960 €

Περιβαλλοντικό Κόστος (Ιδιωτική άρδευσηg)	231,634 €	113,395 €	14,741 €	345,029 €
Κόστος Πόρου (Οργανωμένη άρδευση)	1,347,624 €	-€	-€	1,347,624 €
Κόστος Πόρου (Ιδιωτική άρδευση)	12,128,617 €	-€	-€	12,128,617 €
Κόστος Πόρου (κτηνοτροφία)	246,105 €	-€	-€	246,105 €
Total	**24,298,213 €**	**584,825 €**	**266,029 €**	**24,883,039 €**

Πέρα από την παρουσίαση της εκτίμησης των δύο τροφοδοτικών υπηρεσιών για τα ΥΔ10 και ΥΔ09, μια άλλη παρατήρηση σχετίζεται με τη διαφοροποίηση σχετικά με την εκτίμηση των δύο πρώτων τροφοδοτικών υπηρεσιών (παροχή πόσιμου νερού και παροχή γεωργικών υδάτων) και την τρίτη τροφοδοτική υπηρεσία (νερό για χρήση ηλεκτρικής ενέργειας). Όπως περιγράφηκε παραπάνω, το πλαίσιο που χρησιμοποιήθηκε από τους Koundouri et aϊ. (2016) χρησιμοποιήθηκε για την εκτίμηση των πρώτων υδάτινων οικοσυστημικών υπηρεσιών. Βάσει αυτού, η αξία του νερού βασίστηκε στο άθροισμα τριών κατηγοριών κόστους. Ωστόσο, για την υπηρεσία "νερό για παραγωγή ηλεκτρικής ενέργειας" ακολουθήθηκε μια εναλλακτική προσέγγιση. Ο λόγος πίσω από αυτό συνδέεται με τη φύση του νερού και της ενέργειας ως αγαθών.

Από τη μία πλευρά, το νερό είναι και μια εξαντλήσιμη και ανανεώσιμη πηγή. Αυτό εξαρτάται από την πηγή του νερού, δηλαδή τα επιφανειακά ή τα υπόγεια ύδατα. Ενώ τα επιφανειακά ύδατα είναι μια ανανεώσιμη παροχή, η τροφοδοσία των οποίων εξαρτάται από τις καιρικές συνθήκες, τα υπόγεια ύδατα ανανεώνονται επίσης με διήθηση βροχής ή λιωμένου χιονιού, αλλά τα περισσότερα έχουν συσσωρευτεί σε γεωλογικούς χρόνους και λόγω της θέσης τους δεν μπορούν να ανανεωθούν όταν εξαντληθούν (Gleick, 2000). Επιπλέον, όσον αφορά τα επιφανειακά ύδατα, η κατανομή του περιλαμβάνει την κατανομή σταθερού ανανεώσιμου εφοδιασμού μεταξύ ανταγωνιστών χρηστών, ενώ για την εκμετάλλευση υπογείων υδάτων το νερό επηρεάζει τους πόρους που διατίθενται για τις μελλοντικές γενιές. Επομένως, η κατανομή με την πάροδο του χρόνου είναι μια κρίσιμη πτυχή (Tietenberg & Lewis, 2016).

Με βάση αυτό, το νερό έχει μοναδικά χαρακτηριστικά ως περιβαλλοντικό αγαθό. Πρώτον, υπάρχει μια ιεραρχία σχετικά με τις πηγές εκμετάλλευσης που βασίζονται στο κόστος, τη ζήτηση και τη διαθεσιμότητα. Με άλλα λόγια, τα επιφανειακά ύδατα καταρχήν εκμεταλλεύονται, ενώ τα υπόγεια ύδατα παραμένουν η δεύτερη καλύτερη επιλογή, καθώς είναι λιγότερο αποδοτικά από πλευράς κόστους, αλλά μπορεί να είναι η μόνη επιλογή όπου δεν υπάρχουν επιφανειακά ύδατα. Επιπλέον, υπάρχουν ανταγωνιστικές χρήσεις νερού, όπως περιγράφηκε σε προηγούμενα κεφάλαια. Παρ 'όλα αυτά, δεν υπάρχει παραγωγή νερού, αλλά αναφερόμαστε στην επεξεργασία νερού, τη διατήρηση των ποιοτικών προδιαγραφών ύδατος και την επίτευξη αποτελεσματικής και βιώσιμης κατανομής και διανομής νερού (Tietenberg & Lewis, 2016). Με εξαίρεση την αφαλάτωση, δεν υπάρχει μονάδα παραγωγής νερού υπό την τρέχουσα τεχνολογία αιχμής. Το ζήτημα της ποιότητας καθιστά δύσκολο να "μεταφερθεί" το νερό σε μεγάλες αποστάσεις, οπότε τα ύδατα πρέπει να κατανέμονται σε μια περιορισμένη γεωγραφική περιοχή (Hardberger, 2013).

Από την άλλη πλευρά, η ενέργεια είναι πιο «ευέλικτη» πηγή. Υπάρχουν ανταγωνιστικές πηγές παραγωγής ηλεκτρικής ενέργειας, όπως πετρέλαιο, φυσικό αέριο, φωτοβολταϊκά, άνεμος και νερό. Όλα αυτά μπορούν να παράγουν εναλλακτική "ηλεκτρική ενέργεια". Επιπλέον, η ηλεκτρική ενέργεια μπορεί να μεταφερθεί σε μεγάλες αποστάσεις χωρίς επιπτώσεις στην ποιότητά της. Η ποιότητα δεν είναι καθόλου ζήτημα, δηλαδή δεν υπάρχει ηλεκτρική ενέργεια χαμηλότερης ποιότητας που δεν μπορεί να καταναλωθεί. Ωστόσο, η "ποιότητα" συνδέεται άμεσα με την πηγή της παραγωγής. Συνεπώς, υπάρχει καθαρή ενέργεια που προέρχεται από ανανεώσιμες πηγές ενέργειας όπως ο ήλιος, το νερό, η βιομάζα και το νερό (WWF Ελλάδα, 2017). Άλλες πηγές παραγωγής ηλεκτρικής ενέργειας όπως το πετρέλαιο, ο άνθρακας και το φυσικό αέριο εκλύουν εκπομπές CO_2, οι οποίες είναι επιβλαβείς για το περιβάλλον, μολύνουν την ατμόσφαιρα και συμβάλλουν στο φαινόμενο του θερμοκηπίου και στην αλλαγή του κλίματος. Στη μικροοικονομική θεωρία, οι επιδράσεις αυτές ορίζονται ως εξωτερικές και ο στόχος της περιβαλλοντικής πολιτικής είναι η εσωτερικοποίηση αυτών των επιπτώσεων, έτσι ώστε να αντικατοπτρίζει το πραγματικό κόστος παραγωγής ηλεκτρικής ενέργειας (Μπίθας, 2011).

Επομένως, καθώς δεν υπάρχει ανταγωνιστική παραγωγή νερού, μπορεί κανείς να εξετάσει μόνο την κατανομή του νερού μεταξύ των ανταγωνιστικών χρήσεων ύδατος και του τρόπου με τον οποίο αυτές επηρεάζουν τη βιώσιμη διαχείριση των υδάτων. Για να εκτιμηθούν οι υπηρεσίες οικοσυστήματος που σχετίζονται με το νερό, όπως η παροχή πόσιμου νερού και νερού άρδευσης, το κόστος παροχής νερού σε αυτές τις χρήσεις πρέπει να λαμβάνεται υπόψη, τουλάχιστον σε ένα πρώτο στάδιο (Grizzetti et al., 2016). Λόγω του ότι οι κατηγορίες των υπηρεσιών οικοσυστήματος καθορίζονται λεπτομερώς και επικεντρώνονται σε πολύ συγκεκριμένες παραμέτρους (επιπτώσεις στην ανθρώπινη ευημερία), εκτιμώντας την αξία αυτών των υπηρεσιών παροχής υπηρεσιών μπορεί να ισούται με το συνολικό κόστος παροχής αυτών των υπηρεσιών.

Εκτός αυτού, η παροχή υπηρεσιών "νερό για παραγωγή ηλεκτρικής ενέργειας" έχει άλλα χαρακτηριστικά. Το νερό εδώ χρησιμοποιείται ως εισροή για την παραγωγή ενός αγαθού δηλαδή ηλεκτρισμού που επηρεάζει την ανθρώπινη ευημερία. Παράλληλα, υπάρχουν και άλλες εισροές που παράγουν το ίδιο αγαθό. Στην περίπτωση μας στο ΥΔ09, η ανταγωνιστική πηγή παραγωγής ηλεκτρικής ενέργειας είναι σταθμοί ηλεκτροπαραγωγής με λιγνίτη. Ωστόσο, αυτά συνεπάγονται εκπομπές CO_2, ένα εξωτερικό αποτέλεσμα που πρέπει να ληφθεί υπόψη. Αντίθετα, οι μεγάλες υδροηλεκτρικές μονάδες είναι μια καθαρότερη πηγή ενέργειας, καθώς δεν εκλύουν εκπομπές CO_2 στη διαδικασία παραγωγής. Δεδομένου ότι η ανάλυση των υδάτινων οικοσυστημάτων εξετάζεται κατά την ανάλυση και δεν υπάρχει συγκριτική ανάλυση των πηγών παραγωγής ηλεκτρικής ενέργειας, θα είναι σοβαρή παράλειψη, εάν δεν ληφθούν υπόψη τα περιβαλλοντικά οφέλη από την παραγωγή ηλεκτρικής ενέργειας από μεγάλα υδροηλεκτρικά εργοστάσια. Μελετώντας μόνο την πλευρά κόστους των μεγάλων υδροηλεκτρικών και θεωρώντας ότι είναι ίση με την αξία της παροχής υπηρεσιών οικοσυστήματος, μπορεί να θεωρηθεί ανεπαρκής. Στην περίπτωση αυτή, χρειάστηκε μια πιο ολιστική προσέγγιση, έτσι ώστε οι πρόσθετες θετικές εξωτερικές επιπτώσεις να μπορούν να ενσωματωθούν στην αξία της συγκεκριμένης υπηρεσίας οικοσυστημάτων. Κατά συνέπεια, η αξία της υπηρεσίας παροχής "νερό για τη χρήση ηλεκτρικής ενέργειας" θεωρήθηκε ίση με τα οφέλη της παραγωγής ηλεκτρικής ενέργειας από μεγάλες υδροηλεκτρικές μονάδες, δηλ. Έσοδα από την πώληση της παραγόμενης ηλεκτρικής ενέργειας και τα θετικά περιβαλλοντικά οφέλη από την παραγωγή καθαρής ενέργειας.

Τα αποτελέσματα αποτυπώνονται στον Πίνακα V

Πίνακας V: Εκτίμηση της συνολικής αξίας του οφέλους από τι δραστηριότητες της ΔΕΗ (παραγωγή ηλεκτρικής ενέργειας). Πηγή: : Ειδική Γραμματεία Υδάτων, 2014β.

ΜΥΗΣ	Παραγωγή ηλεκτρικής ενέργειας (€)	Περιβαλλοντικό όφελος (€)	Συνολική αξία (€)
Πολύφυτος	27,781,557 €	6,667,440 €	34,448,997 €
Ιλαρίωνας	24,139,144 €	5,793,278 €	29,932,423 €
Σφηκιά	24,700.496 €	5,928,000 €	30,628,496 €
Ασώματοι	8,450.169 €	2,028,000 €	10,478,169 €
Αγία Βαρβάρα	292,505 €	70,200 €	362,705 €
Σύνολol	**85,363,871 €**	**20,486,918 €**	**105,850,790 €**

Τέλος, υπάρχει και μια τελευταία παρατήρηση σχετικά με την αποτίμηση των υδάτινων οικοσυστημικών υπηρεσιών με τη βοήθεια της Οδηγίας Πλαίσιο για τα Ύδατα. Σίγουρα, το επίκεντρο της Οδηγίας είναι διαφορετικό από αυτό της αποτίμησης των υπηρεσιών οικοσυστήματος. Ειδικότερα, η οικονομική ανάλυση στο πλαίσιο της Οδηγίας επικεντρώνεται τελικά στην εκτίμηση του λόγου ανάκτησης κόστους των διαφόρων χρήσεων ύδατος (WATECO, 2002). Αυτό θα χρησιμεύσει ως βάση τόσο για τις αρχές τιμολόγησης του νερού με βάση την αρχή της πλήρους ανάκτησης του κόστους. Παρά το γεγονός ότι υπάρχουν εννοιολογικά πλαίσια που χρησιμοποιούν την Οδηγία Πλαίσιο ως εργαλείο για την αξιολόγηση των οικοσυστημικών υπηρεσιών που σχετίζονται με το νερό (Bastian et al., 2012, COWI, 2014, Wallis et al., 2011), υπάρχει ένα καθαρό οντολογικό ζήτημα σχετικά με την ανάγκη αποτίμησης των υπηρεσιών οικοσυστήματος. Ασφαλώς, υπάρχουν ανησυχίες σχετικά με τον τρόπο με τον οποίο αυτή η αποτίμηση μπορεί να χρησιμοποιηθεί πρακτικά. Η Οδηγία έχει θέσει σαφείς στόχους σε αυτόν τον τομέα, αλλά οι μελετητές διαφώνησαν για το θέμα αυτό. Ο Kallis et al. (2013) που ασχολείται με την ερώτηση "to value or not to value?" αναδιατύπωσε την ερώτηση ως "πότε και πώς να γίνει χρηματική αποτίμηση;" και "υπό ποιες συνθήκες;". Ως εκ τούτου, διαμορφώθηκαν τέσσερα κριτήρια για οικονομική αποτίμηση (Kallis et al., 2013):

- βελτίωση του περιβάλλοντος.
- διανοητική δικαιοσύνη και ισότητα;
- τη διατήρηση θεσμών που εκφράζουν την πληθυντική αξία.
- Αντιμετώπιση της εμπορευματοποίησης υπό τον νεοφιλελευθερισμό.

Βάσει αυτών των κριτηρίων, τόσο η τιμολόγηση πλήρους κόστους σύμφωνα με την Οδηγία Πλαίσιο για τα Ύδατα όσο και για τις υπηρεσίες πληρωμών για υπηρεσίες οικοσυστημάτων (Payment for Ecosystem Services- PES) δεν πληρούν και τα τέσσερα κριτήρια και συνεπώς η οικονομική τους αξιολόγηση δεν πρέπει να πραγματοποιηθεί. Ωστόσο, υπάρχει περιθώριο βελτίωσης καθώς η οικονομική αποτίμηση μπορεί να βαθμονομείται και να προσαρμόζεται ώστε να συμμορφώνεται με τα τέσσερα κριτήρια (Kallis et al., 2013).

Έτσι, μπορεί να υποτεθεί ότι η οικονομική αποτίμηση και ειδικότερα η οικονομική αξιολόγηση των υπηρεσιών οικοσυστήματος δεν θα μπορούσε να απορριφθεί a priori. Ωστόσο, θα πρέπει να είστε προσεκτικοί, πότε να χρησιμοποιήσετε αυτή την οικονομική αποτίμηση ως μέσο προς ένα ορισμένο τέλος.

Γενικότερα, η οικονομική αποτίμηση των υπηρεσιών οικοσυστήματος και συνεπώς η περιβαλλοντική ευημερία είναι ένα εργαλείο περιβαλλοντικής ευαισθητοποίησης. Αν και η κοινωνική αντίληψη της περιβαλλοντικής ευημερίας για τη συνολική ευημερία γίνεται αντιληπτή, η έλλειψη αποτίμησης μπορεί να υπονομεύσει αυτή τη συμβολή. Εκτός από οποιεσδήποτε θετικές ψυχολογικές επιπτώσεις, η μη αναγνώριση των βασικών διαστάσεων της περιβαλλοντικής ευημερίας οδηγεί σε άμεση και έμμεση υποβάθμιση του περιβάλλοντος και κάθε προσπάθεια προστασίας του. Με τον τρόπο αυτό, η εκτίμηση των οικοσυστημικών υπηρεσιών από οικονομικής πλευράς αποδίδει πρωτίστως μια τάξη μεγέθους για το σχετικό μέγεθος της περιβαλλοντικής ευημερίας, τονίζει την αξία της περιβαλλοντικής προστασίας και κατ 'επέκταση την περιβαλλοντική πολιτική και πρέπει να είναι ένα μέσο περιβαλλοντικής ευαισθητοποίησης, πληροφόρησης και την εκπαίδευση (Τράπεζα Πειραιώς, 2017).

Το επόμενο βήμα μετά την ευαισθητοποίηση είναι η προσεκτική σύνταξη των αρχών και των στόχων της περιβαλλοντικής πολιτικής, όπου η οικονομική αποτίμηση θα χρησιμεύσει ως θεωρητική βάση για την εισαγωγή μιας νέας πολιτικής τιμολόγησης του νερού ή νέων περιβαλλοντικών τελών και φόρων. Εν πάση περιπτώσει, η οικονομική αποτίμηση μπορεί να αποτελέσει το θεμέλιο, με βάση το οποίο μπορούν να σχεδιαστούν και να εφαρμοστούν νέες πολιτικές και να προσαρμοστούν ώστε να συμμορφώνονται με τους πολιτικούς στόχους.

Στο προτελευταίο κεφάλαιο περιγράφηκε η πολύπλοκη φύση του δεσμού ύδατος-ενέργειας. Το κύριο ερώτημα θα ήταν βασικά πώς θα μπορούσε να οριστεί το λεγόμενο “water energy nexus”και πώς θα μπορούσε να περιγραφεί αυτό. Επιπλέον, θα μπορούσε αυτό το παράδειγμα να συμβάλει στον σχεδιασμό πολιτικών για το νερό και την ενέργεια που θα μπορούσαν να εξασφαλίσουν τη βιωσιμότητα των υδάτινων πόρων αφενός και την αποδοτική και καθαρή παραγωγή ενέργειας αφετέρου; Τέλος, υπήρξαν κάποια διδάγματα;

Οι ΗΠΑ ήταν μια τέλεια μελέτη περίπτωσης για να δείξουμε πώς το νερό επηρεάζει την παραγωγή ενέργειας και πώς επηρεάζεται η παροχή νερού από την ενέργεια. Διαφορετικές πτυχές του δεσμού αναλύθηκαν και ήταν σαφές ότι σε όλες σχεδόν τις περιπτώσεις μία συγκεκριμένη απόφαση από την πλευρά του νερού του μπορούσε σαφώς να επηρεάσει την πλευρά της ενέργειας του συνδέσμου. Αυτή η αλληλεξάρτηση έχει μεγάλη ομοιότητα και ταιριάζει απόλυτα με την έννοια της συν-εξέλιξης (Norgaard, 2006). Και οι δύο πλευρές του συνδέσμου θα πρέπει να εξελιχθούν μαζί και είναι συναφείς και αλληλεξαρτώμενες. Κατά συνέπεια, μια απόφαση που βασίζεται σε αρχές βιωσιμότητας για ένα τμήμα της σχέσης ύδρευσης μπορεί να έχει θετικά αποτελέσματα σε άλλα τμήματα του συνδέσμου.

Από τη μία πλευρά διερευνήθηκε η πτυχή της «ενέργειας για νερό». Με άλλα λόγια περιγράφηκαν οι ενεργειακές ανάγκες στα διάφορα στάδια του νερού. Αυτά παρουσιάζονται μόνο για την πολιτεία της Καλιφόρνια στον Πίνακα VI

Πίνακας VI: Συνολική χρήση ηλεκτρικής ενέργειας από τον τομέα νερού στην Πολιτεία της Καλιφόρνια σε GWh. Πηγή: US DOE, 2014; CEC, 2005; Bennett et al., 2010.

Στάδιο του κύκλου του νερού	CEC Study 2005	CEC Study 2006	Bennett et. al. 2010
Προσφορά- άντληση	10,742	10,371	15,786/172
Μεταφορά			
Επεξεργασία			312
Διανομή			1,000
Επεξεργασία λυμάτων	2,012	2,012	2,012
Συνολική χρήση ηλεκτρικής ενέργειας από τον τομέα νερού	12,754	12,383	18,282
% των συνολικών απαιτήσεων σε ηλεκτρική ενέργεια σε επίπεδο πολιτείας	5.1%	4.9%	7.7%

Από την άλλη πλευρά, εξετάστηκε η πλευρά του νερού για ενέργεια. Πιο συγκεκριμένα αναλύθηκαν το πόσο νερό χρειάζεται για την παραγωγή ηλεκτρικής ενέργειας. Αν και δεν έχει επισημανθεί, το νερό αποτελεί ένα από τα απαραίτητα στοιχεία έτσι ώστε να μπορεί να πραγματοποιηθεί η παραγωγή ηλεκτρικής ενέργειας. Σε αντίθεση με το νερό η ηλεκτρική ενέργεια είναι ένα αγαθό που παράγεται από διάφορες πηγές και σχεδόν σε όλες τις περιπτώσεις το νερό αποτελεί μέρος της παραγωγικής επεξεργασίας και διεργασίας για την παραγωγή ενέργειας (USGS, 2014). Για αυτό το λόγο εξετάζονται οι παρακάτω μορφές/ φορείς ηλεκτρικής ενέργειας (USGS, 2014):

- Άνθρακας
- Φυσικό αέριο
- Ουράνιο

- Θερμοηλεκτρικής ενέργεια
- Πετρέλαιο
- Βιοκαύσιμα

Αυτοί είναι οι βασικές μορφές παραγωγής που εξετάζονται καθώς άλλες μορφές ενέργειας απαιτούν σχετικά ελάχιστες ποσότητες ύδατος. Στον Πίνακα VII

Πίνακας VII: Απορροές και κατανάλωση θερμοηλεκτρικών σταθμών παραγωγής ενέργειας από τύπους συστημάτων παραγωγής και ψύξης όπως μοντελοποιήθηκαν από την Αμερικάνικη Γεωλογική Υπηρεσία για το 2010 σε εκ. γαλόνια την ημέρα. Πηγή: USGS, 2014.

Απορροές	Σύστημα ανοικτού τύπου-υφάλμυρο νερό	Σύστημα ανοικτού τύπου-πόσιμο νερό	Ανακυκλούμενο σύστημα-λίμνη	Ανακυκλούμενο σύστημα-πύργος	Περίπλοκες διαδικασίες	Σύνολα
Πετρέλαιο	659	21	NA	1	NA	681
Ατομική ενέργεια	17.019	15.405	166	605	NA	33.196
Σύνθετος Κύκλος Φυσικού Αερίου (NGCC)	1.213	446	16	384	NA	2.06
Φυσικό αέριο	1.209	2.442	21	32	NA	3.704
Άνθρακας	2.363	49.489	187	1.259	NA	53.298
Περίπλοκες διαδικασίες	NA	NA	NA	NA	35.753	35.753
Σύνολο	22.463	67.803	390	2.283	35.753	128.692
Κατανάλωση						
Πετρέλαιο	NC	0.2	NA	0.8	NA	1
Ατομική ενέργεια	NC	157	166	433	NA	756
Σύνθετος Κύκλος Φυσικού Αερίου (NGCC)	NC	5	16	268	NA	288
Φυσικό αέριο	NC	27	21	23	NA	71
Άνθρακας	NC	503	187	867	NA	1.557
Περίπλοκες διαδικασίες	NA	NA	NA	NA	832	832
Σύνολο	NC	692	390	1.591	832	3.505

Παράλληλα, το παράδειγμα της αφαλάτωσης μπορεί να επικυρώσει την υπόθεση της λεγόμενης «συνεξέλιξης» μεταξύ του νερού και της ενέργειας. Η αφαλάτωση του νερού μπορεί αναδύεται ως εναλλακτική λύση βιώσιμης ύδρευσης. Αυτό οφείλεται κυρίως σε δύο γεγονότα, την αλλαγή του κλίματος και την αύξηση του πληθυσμού. Καθώς οι υδροφόροι ορίζοντες και οι υδάτινοι πόροι παραμένουν λιγοστοί και πρόκειται να εξαντληθούν, παράλληλα με τον αυξημένο πληθυσμό κυρίως στις αστικές περιοχές, τα κέρδη αφαλάτωσης του νερού αποτελούν ακόμη προτιμότερη επιλογή. Εντούτοις, πρέπει να ληφθούν υπόψη ορισμένοι παράγοντες, διότι η ανάπτυξη της αφαλάτωσης συνδέεται με περιβαλλοντικές, κλιματικές αλλά και κοινωνικές ανησυχίες. Αν αυτά αντιμετωπιστούν και αποσαφηνιστούν σε κάποιο βαθμό, τότε η αφαλάτωση μπορεί να θεωρηθεί όχι μόνο ως βιώσιμη αλλά και ως βιώσιμη λύση για την παροχή νερού.

Πίνακας VIII: Κατανάλωση Ενέργειας και Μέσο Κόστος Νερού για Εμπορικές Αφαλατώσεις Μεγάλης Κλίμακας. Πηγή: Ziolkowska & Reyes, 2017.

Διαδικασία	Θερμική ενέργεια	Ηλεκτρική Ενέργεια	Σύνολο Ενέργειας	Κόστος Επένδυσης	Συνολικό Κόστος νερού
	(kWh/m^3)	(kWh/m^3)	(kWh/m^3)	(\$/m^3/day)	(\$/m^3)
‘Άμεση Διύλιση πολλαπλών σταδίων (MSF)	7.5-12	2.5-4	10-16	1200-1500	0.8-1.5
Εξάτμιση με πολλαπλές βαθμίδες (MED)	4-7	1.5-2	5.5-9	900-2000	0.7-1.2
Αντίστροφη Όσμωση (θαλασσινό νερό)	-	3-4	3-4	900-2500	0.5-1.2
Αντίστροφη Όσμωση (υφάλμυρο)	-	0.5-2.5	0.5-2.5	300-120	0.2-0.4

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Chapter 1: Introduciton

"Thousands have lived without love, not one without water."

Wystan Hugh *Auden (1907- 1973)*

Chapter 1: Introduction

Sustainability in Aquatic Ecosystems; The interaction between economic, social and environmental systems: Case studies from Europe and the U.S.A.

1 Introduction

Aim of the thesis is the description and analysis of sustainable development through intergenerational and intragenerational justice. Based on that analysis, it will be shown that the concepts such as the Ecosystems Services Framework (ESF) and the water-energy nexus can sufficiently explain how sustainability is attained in aquatic ecosystems. Therefore the main research question is: How can sustainable development be attained in aquatic ecosystems? Is a concept or a theory sufficient to describe the sustainability of those ecosystems?

Firstly, sustainable development in aquatic ecosystems will be analysed. The foundations facilitating the research process will be set by presenting a primer on sustainable development, whose focus of attention will be reserved for those specific traits of sustainability that will assist in developing a framework for describing the fulfilment of sustainability within aquatic ecosystems.

Secondly, the interaction between the economic, social and environmental dimension will be presented. This is more or less an interpretation of the definition of sustainable development and sustainability. Here lies the complexity of sustainable development in comparison with other concepts and theories. Sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" as stipulated in the Brundtland report. Such definition is open to various interpretations, which is beneficial to scientific research but very harmful to policy implementation. The research will take advantage of the ambiguous nature of sustainable development, but will not be limited to the classic "dipole" of "weak-strong" approach of sustainable development. A "less travelled road" will be followed, where other disciplines will be examined in order to determine how economic, social and environmental dimension interact for the attainment of sustainable development. These alternative disciplines have long researched questions that were mainly related to individuals, human well-being and justice. By considering those questions, the question of sustainable development has emerged. A detailed look at this will follow. One specific and common trait of those disciplines and the concept of sustainability is the existence of human beings who in turn define and give value to nature. If human beings had not theoretically existed, then there would have been no need in employing different theories on individuals, society, economy and their relation to nature.

Thirdly, case studies from Europe and the United States cases will be analysed. This area of the research follows the theoretic interpretation of sustainable development. As sustainable development was articulated as an interaction between social, economic and environmental system, the result would be a framework based on which the attainment of sustainability can be assessed. Therefore, the result of this theoretical analysis should be a concept, an approach or even a metric. This will assist in explaining the main research question, i.e. the attainment of sustainability. A basic question here is if one metric or one approach is sufficient for explaining the main research question. Possibly, one approach is not sufficient and multiple frameworks can be utilised so as to check the primary hypothesis. Such approaches should be in any case context specific and it will surely help if these are universal, i.e. if these are applicable in almost all cases. The results of those analyses will show their success. Success can be in our case not of an objective nature. This does not mean that such concepts should be rejected. On the contrary, the results can shed light on specific elements of sustainability and be analysed and employed accordingly. What these results show and how these can be employed in a prospective policy implementation is another topic, which could be further described. All in all, it can be assumed, that this thesis expects to use the results of the analyses to address the main research question explaining the multi-faceted nature of sustainable development.

The next chapters are dedicated to explaining the basic research areas of the PhD thesis, as they were presented in the three sections of the title. In every sentence, the main argument, thesis will be presented, while the respective questions and assumptions for each step of the research process will be articulated.

1.1 Sustainable Development in Aquatic Ecosystems

Sustainable development has been defined as the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. (WCED, 1987).

This is considered as the most well-known definition of sustainable development. At first glance, it seems that the definition of this term is very robust and its notion can be clearly explained. However, one should bear in mind that the definition was included in the so-called “Brundtland Report” in 1987, a policy document. Such policy documents are not solely scientific research reports, but documents that aim to describe prospective policies. Consequently, there was an urgent need to reconcile diverging opinions and views that were based on the theoretical background one politician and/ or researcher had.

Although it was based on a seemingly robust definition, sustainable development appeared with multiple interpretations after the publication of the Brundland report. Numerous reports, and policy documents used this definition as the basis for expressing the opinion and aims of the respective authors. Hence, sustainable development proved to be greater than the sum of its parts. Its “cogs and wheels” proved to be unique and contingent on the beliefs of each researcher, politician and organisation.

One plausible question that arose after this brief description is: What had happened before this definition emerged? Was this newly found term the result of policy experience of the previous decades? Did it aim at summarising and including already implemented concepts and theories? Where did it originate?

These questions lead to the historical roots of the term sustainability and sustainable development being presented. One hypothesis is that the term sustainable development was not something new but was employed indirectly on specific occasions and with certain disciplines. Furthermore, sustainability and sustainable development could have formed a core element of a specific policy, but it was not hailed as the primary goal of that policy nor was it generalised to embrace all aspects of environmental policy. In any case, sustainable development was directly interconnected with environmental policy.

Additionally, a further question that emerges is how this term was interpreted and analysed for it to become a general policy goal. Why was such a definition formulated? Which need urged policy makers and scientists to define this concept?

Therefore, the process of introducing the term in the policy agenda should be described. The first impression here is that increasing environmental problems after the Second World War created an increased inquietude among the people. However, other factors, basically related to politics, have contributed to its emergence.

Finally, another question of prime importance is how this definition of sustainable development was employed and implemented. Did the term retain its core elements? How has it contributed as a main policy goal? Was its position further weakened or strengthened throughout the recent years?

Therefore, the evolution and implementation of the notion of sustainable development during the last 20 years, since the publication of the Brundtland Commission in 1987 should be analysed. Here it can be assumed that sustainable development was finally integrated as a policy goal. This can be seen as a first success. However, the open interpretation of the term sustainable development had as an effect that the concept was modified and adapted to the needs and policy goals of each respective policy maker and organisation. This could mean that the concept could distance itself from its core principles and its ambitious policy goals were limited to the production of policy documents, with no practical policy implementation..

1.2 Interaction between economic, social and environmental dimension

As described above, the interaction between economic, social and environmental dimension is basically an interpretation of the sustainable development definition. One of the assumptions made above was that the term sustainable development is not robust but open to numerous interpretations. Consequently, the next question that emerges is what interpretation of sustainable development this PhD thesis should attempt to analyse. Furthermore, how can this selection be explained? What are the parameters that direct the research to that?

There seems to be an increasing interest from other disciplines on the matter of sustainable development. At a first stage, the interpretation of sustainable development through the lens of intergenerational justice will be attempted. Disciplines such as practical philosophy, economics and sociology have focussed their research on that topic and it has been the subject of inquiry for many scientific disciplines according to their respective scientific tradition.

There are specific arguments with regard to the selection of interpretation. One basic argument in favour of that selection concerns the nature of sustainability. Sustainable development is more or less directly correlated with issues related to environment and pollution. Nevertheless, there is also the economic and social dimension that needs consideration. Surely, the emphasis on the environment was basically the “policy innovation” that made sustainable development a unique concept. But, it can be argued that sustainable development is a question of interaction and interdependency among these three dimensions. More specifically, sustainable development focuses on the interaction between human beings and nature. Human beings exploit and use nature and its resources for their own benefit. As result, the existence of human beings is the “raison d’être” behind sustainable development. If humans had not existed, there would have been no need for consideration of the environment. Therefore, the focus remains on the interactions among these three systems. Additionally, environment is viewed as the “means to an end”, based on which the needs of human beings are satisfied. In the final analysis, satisfaction of needs and attainment of well-being (at a sufficient level) that is contingent on the environment and its resources, lie at the core of sustainable development.

It would be useful then to look at other disciplines that have been engaged in questions relating to intergenerational justice, i.e. the justice between generations. However, an extensive analysis of this term presenting its historical development of the term and a detailed analysis of the existing different contemporary perspectives of intergenerational justice are not only beyond the scope of the thesis but are essentially disorientating. It is assumed, then, that individual elements of the concept of “intergenerational justice” can be successfully employed so as to express sustainability in terms of that concept.

Further questions that are related to intergenerational justice are how much do we sustain and how much should we sustain?” If those two questions are answered then the research question can be sufficiently answered. More specifically, the main question of is merely deontological. In other words, should the current generation bequeath something to the next generation and if so how?

The process of answering that question is not straightforward, as sustainability enters the equation of intergenerational justice. It is assumed that a mere presentation of different theories should be rejected and a more selective process should be employed. Ideally, a concept or even a certain principle stemming from that disciplines may be useful in order to “translate” sustainability in terms of intergenerational justice. It is of primary interest to identify a theory that describes how at least a minimum level of well-being, a threshold can be passed on to the next generation from the previous generation.

After presenting a comprehensive approach of how sustainability can be integrated in the context of intergenerational justice, the next area of inquiry should aim at analysing a specific trait of the term “sustainable development”. This crucial area of inquiry will address the question: What do human beings consider as important for their own well-being that is also consequently crucial for sustaining and passing on the next generations? And yet, another question: Are there specific needs that should be satisfied in order for an individual to attain a certain “threshold” of well-being”?

The analysis considers approaches that primarily focus on intragenerational justice, i.e. justice between individuals and/or groups of one generation. A hypothesis: There are interesting approaches that will provide the necessary feedback and input in order to proceed with the formation of a similar to the approach influenced by intergenerational justice.

The next question then arises: How is a threshold for this person defined? Are there any theories that specify the basic needs of a human being?

It is expected that there will be different approaches to answer this. Opinions may vary from the definition of a predetermined list of basic needs to a more vague approach that avoids defining specific traits of human basic needs. Additionally, all selected approaches should be presented in order not only to identify and to merge their elements but also to attempt to explicitly or implicitly integrate the concept of sustainability.

After analysing the notion of sustainability and looking into the concept of well-being, the analysis aims to focus on concepts and metrics relating directly or indirectly to sustainable development. Is there such a metric? How is sustainability expressed within this framework and how is well-being assessed?

This area of inquiry has its focus on the Ecosystem Services (ES) Framework. The reason for using this concept is that one can view Ecosystem Services as an instrument, with which “well-being” can be attained. “Well-being” will be defined as “the meta- capability” that ensures the necessary conditions for the attainment of the basic capabilities. Also, the Ecosystem Services Framework attributes to merge and integrate both sustainability and well-being. Primarily, it seems that the Ecosystem Services Assessment takes the notion of sustainability for granted, as sustainability constitutes a foundation of the ES concept, it being accepted as one of its priorities. However, it is interesting that the term is not restricted anymore to ecological stability. Sustainability enters the “realm” of well-being and is investigated as such. There is a clear tendency to operationalise Brundlandt’s notion of sustainability, which is merely the definition of sustainable development, and is expressed in Ecosystem Services Assessment as “sustained well-being”.

Therefore, the Ecosystem Services Framework will be presented. More specifically, the basic characteristics, purpose, categorization and development throughout the last fifteen years will be presented. Additionally, a specific and very interesting trait of the ES Framework is analysed. This trait is the concept of justice. Expressed in “well-being” terms, the focus should be on how the application of ES ensures the satisfaction of human well- being.

In summary, the starting point of the analysis will be that of intergenerational justice and it will proceed to the topic of intragenerational justice. Finally, an approach that is more related to the topic of sustainable development will be described. But this will be no mere presentation of an approach. The ES Framework will adopt elements of the previous research so as to articulate an intuitive definition of sustainable development as a "sustained well-being".

1.3 Case studies from Europe and the United States cases.

The last step of the research process is the practical application of the ES framework and other concepts that focus on sustainability. The first question that arises: Is there is a case study example of how ecosystem services can be thereby assessed leading to a monetary valuation.? Other question of the chapter: How can ES be applied in practice? How can existing concepts and policies help formulate the value of ecosystem services? How can the valuation of ES be used further for policy making?

The practical application of the ES Framework is to utilise Water Basin Management Plans (WBMP) in the Water Districts of Central and Western Macedonia. It should be noted that within the frame of the European Water Framework Directive (WFD), all Member States are obliged to compose Water Basin Management Plans (WBMP). These management plans will be the reference based on which the "translation" into ES will take place.

However, an important addition, the search for a basic theoretical framework, is needed in order to proceed with this analytical process. This framework will constitute the basic pillar and will argue in favour of such an analysis. It is highly desired for there to be more than one concept, with which Water Basin Management Plans can be reformulated so as to provide the basis of bringing Ecosystem Services into practice.

The main part of the analysis is dedicated to a thorough economic valuation of water ecosystem services in the Water Districts of Central and Western Macedonia. The primary research has been conducted within the frame of composing the Water Basin Management Plans for the aforementioned Water Districts and more specifically the economic valuation and cost recovery ratio for all water uses. The next step is to use those values to assess the value of specific water-related ecosystem services. This analysis is the first of its kind in Greece and is expected to provide a theoretical approach on water- related ES valuation. It should be noted that the author was involved in the primary research. Therefore, after the analysis a critical review of the values along with a critique of the theoretical concept will follow.

Since sustainable development and sustainability is not a robust concept, this PhD thesis aspires to exploit this vagueness and to present a further approach that directly intertwines with those terms. Therefore, the analysis will conclude with the description of the water-energy nexus paradigm. Water- energy nexus was first described by Peter Gleick (1994): water is used for energy production, while energy is also employed for many aspects of water, such as its production and treatment. The main question will be basically how water-energy nexus can be defined and how it can be described. Furthermore, can this paradigm assist in designing water and energy efficient policies that can secure the sustainability of water resources on the one hand and the efficient and clean production of energy on the other hand? Finally, are there any lessons learnt?

In contrast with the previous practical application, this last part of the research will be dedicated to a thorough analysis of the water-energy nexus and the multi-faceted aspects for that relationship. In no case is this paradigm constrained to a small number of categories. Focus of the analysis will be the United States of America (USA), where the concept has been examined in detail. Apart from that US is a country, which possesses many distinct features and many regional particularities that render this concept extremely important. More specifically, two basic categories will be investigated: water for energy and energy for water.

Furthermore, an aspect of the energy-water nexus will be described. This concerns water desalination, which is defined as the treatment of seawater and brackish water for its conversion to freshwater. Despite the fact that water desalination has currently a very marginal role in the water-energy nexus, it is expected that it will be of emerging importance in the near future, as many regions in the US and in the world will be faced with a water-shortage, due to water stress and exhaustion of freshwater sources that will have been further amplified by climate change and demographic parameters.

The PhD thesis will conclude with a discussion on research presented in all steps. The basic question is: Have the questions for each respective topic been successfully addressed and have the primary assumptions been validated? In other words, was sustainable development successfully formulated? Did the insights from inter- and intragenerational justice assist in formulating sustainable development? Did the practical application from Europe and the US. contribute to that goal? It is expected that the basic thesis statement can be addressed. Surely, there can be no single answer to the questions since the research has followed an alternative approach. Such an alternative view will aim at enriching the scientific discussion on that research field and open new research questions for the future.

1.4 Uniqueness and innovation of the PhD Thesis

This PhD thesis is expected to present two novelties that aim to contribute to the current scientific dialogue on sustainable development. The first novelty is theoretical and the other practical.

The theoretical novelty is mainly related to the interpretation of sustainability with terms "borrowed" by other non-related disciplines. Disciplines such as practical philosophy, sociology and economics are identified. It is assumed that those disciplines may offer interesting insights and traits that can be integrated into the scientific dialogue on sustainability. Two specific subjects that have been the focus of research for those disciplines are intergenerational and intragenerational justice. Both topics have been the research focus of those long before the idea of sustainable development was conceived. The scientific tradition and dialogue on issues on justice were initiated even before the classical era in Ancient Greece and they have been revamped in the 20th century. Therefore, it would be an interesting task to focus on those subjects and identify traits that will assist in explaining sustainable development in other terms.

Those disciplines have surely contributed to the formation of sustainable development, as these are older than disciplines such as environmental and ecological economics and policy or social ecology. Nevertheless, due to the increased specialisation of each discipline, it would be useful to look into the latest developments on those and underline which arguments and features are of greatest importance. This also complies with the nature of sustainable development that embraces interdisciplinary research. Even its notion as a concept requires the contribution and combination of various domains. Consequently, the PhD thesis respects the basic principles of sustainable development research and aims to take advantage of that trait.

The fundamental theoretic contribution can be summarised as the interpretation of sustainable development with the help of inter- and intragenerational justice. More specifically, an attempt was made to look into the research questions of both topics and adapt them to the research questions of the PhD thesis. However, the research will not attempt to describe any possible feature of both topics. Intergenerational justice concerns questions related to what the current generation should bequeath to the next generation, how this allocation should take place and if this allocation is justified. These three simple research questions have created an endless and inexhaustible discussion. In relation to intragenerational justice, the question here is which are the basic human needs and how these can be defined. But the research of the PhD thesis has an important and very specific limitation: sustainable development. This factor will confine the research to very specific niche of those topics. Therefore the questions are adapted as to what and how to sustain and whether a specific level of well-being can be defined.

The practical novelty is mainly related to the first case study. As it was described above, the Water Basin Management Plans (WBMP) in the Water Districts of Central and Western Macedonia within the frame of the European Water Framework Directive (WFD) will be described and afterwards the ES framework will be applied.

This research process consists of two basic steps. The first is the conduct of the economic analysis of various water uses in the Water Districts of Central and Western Macedonia. This is primarily a research that involves interviews and questionnaires on economic data from local Water Authorities, agricultural organisations and industries. The main aim here is to calculate the cost recovery ratio for different water uses.

The second step aims at using this economic analysis and applying it to the ES framework. Here it is assumed that the water uses are viewed as different ecosystem services. The cost of supplying water to different uses is equal to the value of the related ecosystem service. In other words, the cost of water for irrigation is deemed equal to the value of the ecosystem service “water for agricultural use”. It is expected that a specific number of water uses can be valued and therefore estimated as ecosystem services.

One could advocate that only the first step suffices, as even this primary research is “per se” a novelty. Surely, for the first time all water uses in the Water Districts of Greece will be estimated. Nevertheless, the PhD thesis proceeds with a further novelty. Water related ecosystem services will be estimated on the economic analysis of WBMP. Additionally, there is a rationale behind this second research step. After the expedition through other disciplines, the PhD thesis attempts to return to disciplines that are related to sustainable development and test how the insights from the disciplines of practical philosophy and sociology can be distilled and summarised with a specific concept of metric. ES framework may fit the research needs if it is adapted accordingly. Even this linking between theory and practice may prove as an additional novelty of this thesis.

With all that has been stated, it can be advocated that the PhD thesis offers theoretical and practical novelties that argue in favour of the realisation of the research and analysis.

1.5 Possible emerging problems

There are a number of barriers and difficulties that are expected to emerge during the research process. Once more, the challenges are both on the theoretical and the practical side.

The challenge concerning the formulation of a theoretical framework on sustainable development is mainly related to the approach chosen. As it was stipulated above, a “road less travelled” will be chosen. This means that the PhD thesis will focus basically on disciplines that were engaged in a scientific dialogue that is very different. Practical philosophy and sociology aim at answering questions that are not directly correlated with sustainability. Such research requires at first to know the “cogs and wheels” and then to delve into deeper research. Here lies the difficulty, as it is quite easy to find oneself in a “labyrinth” of theories and approaches. Consequently, a very careful consideration of those theories and approaches is demanded.

The most crucial question that needs to be answered is: How can sustainability be expressed and translated in terms of inter- and intragenerational justice? It is not sufficient to find a trait or feature of certain concepts that can possibly fit the research purposes. On the contrary, there should be enough theoretical foundation or even a direct reference to sustainable development. Despite the fact that there are indications that such a concept or theoretical framework exists, the research process should overcome caveats that can direct the research in the wrong direction. In general, the basic priority of the research should be to identify and “borrow” a framework that fits as well as possible to the research questions.

The second challenge is mainly related to the primary research on the economic analysis of the WBMP. Firstly, the administrative regions, where the Water Districts are located, cover a vast surface. Consequently, this includes many different water uses and numerous authorities that are in charge of water provision. Even their identification can be seen as a great challenge.

Furthermore, there is an administrative development that might create difficulties in relation to data collection. The latest administrative reform “Kallikratis” that was implemented in 2011, foresaw that many former communities and municipalities are merged into new and greater administrative entities. This also means that many public services such as water provision are also merged. In many cases, it is expected that newly reformed municipalities and communities will integrate services, where no data are available. This can be the case for water provision services as some water authorities with very detailed economic data are urged to include and be merged with other water authorities that did not hold record of any of their actions. This poses a further challenge due to the fact that although there are no economic data, investments, costs and revenues from those services exist and must be estimated. Apart from that, it is apparent that many water authorities will not be willing to share any of their financial data, raising different excuses. Even in that case, a method and procedure should be found so as their economic performance can be estimated.

A further similar problem is merely linked with the water use for irrigation. Principally, regulation of water provision is administered by the Local Land Reclamation Organisations (TOEB). Experience on that field has proven that TOEBs are not fully operational entities. Rarely is there specialised personnel that could provide data on water irrigation. So, even when there are respective spokespersons, it is questionable whether they can provide the research with the necessary input. Also in that case, a similar estimation procedure should be followed while alternative information sources should be identified.

A third challenge is how to carry out the processing of the data provided by the economic analysis of the WBMP. As explained above, the second step of the analysis involves the formulation of economic data into ecosystem services values. Ideally, a theoretical framework that justifies this processing should be found. This is a very specific research that might prove vain and fruitless. Although an increased effort is needed, an alternative approach should be opted so as the second process can be sufficiently justified.

1.6 Expected results

In general, it is expected that the PhD thesis will possibly conclude to a formulation of sustainability and how this can be attained under certain circumstances. Furthermore, this argument is fully expected if the partial results of the research are validated.

With respect to sustainable development, the concept seems to have been employed indirectly in specific instances and within disciplines in the past and it should have been directly interconnected with environmental policy. Furthermore, the open interpretation of the term sustainable development had as an effect that the concept was modified and adapted to the needs and policy goals of each respective policy maker and organisation.

In relation to intergenerational justice, the research will strive to show that there are approaches that will provide the necessary feedback and input so as to proceed with the formation of a definition of sustainable development that is influenced by intergenerational justice.

In relation to intragenerational justice, in order for an individual to attain a certain “threshold” of well-being”, there will be either a predetermined list of basic needs or a more vague approach that avoids defining specific traits of human basic needs that integrate sustainability explicitly or implicitly. It is expected that there will be more than one concept that will fit into the research criteria.

In relation to ES Framework, it is desirable to justify that ES are seen as an instrument, with which "well-being" can be attained. "Well-being" will be successfully defined as "the meta-capability" that ensures the necessary conditions for the attainment of the basic capabilities.

In relation to the first case study on water related ES in the Water Districts of Central and Western Macedonia, the primary research on the Water Basin Management Plans (WBMP) in the Water Districts of Central and Western Macedonia will be carried out. Despite the difficulties the first stage of the research will be completed. Additionally, the second step of the process, the estimation of water ES is expected to be determined using a theoretical approach.

In relation to the second case study on the water- energy nexus in the U.S., it is desirable that despite the fact that water desalination has currently a very marginal role in water-energy nexus, it is expected that it will be of emerging importance in the near future, as many regions in the US and in the world will be faced with a water-shortage. Furthermore, the thorough description of the interconnection between water and energy will reveal how water and energy are two systems very interrelated and additional systems science approach is needed for their observation.

1.7 Structure of the PhD thesis

The structure of the PhD thesis is as follows:

Chapter 2 will present a primer on sustainable development. Firstly, the historical roots of the term sustainability and sustainable development will be presented. Secondly, the process of introducing the term in the policy agenda will be described. Thirdly, the evolution and implementation of the notion of sustainable development during the last 20 years, since the publication of the Brundtland Commission in 1987, will be analysed.

Chapter 3 is dedicated to intergenerational justice**.** The chapter begins with a short introduction of the term "intergenerational justice". What is and isn't intergenerational justice according to the latest scientific dialogue? Then, the chapter will be dedicated to John Rawls and his attempt to explain and formulate a theory of intergenerational justice. The main points of his theory will be presented. In addition, Rawls' theory will be viewed in a way that elements from the theory will be finally exploited so as to express sustainability in terms of intergenerational justice. This chapter will be based on the assumption of Axel Gosseries that sustainability can be translated as a sufficientary principle.

Chapter 4 will describe intragenerational justice. The chapter begins with a thorough description of Amartya Sen's approach, known as the Capability Approach. Its main traits as well as its premises will be described. Similar to that approach, Martha Nussbaum's approach on basic needs will be presented, as both scientists together have initiated the development of that approach. Nevertheless, Nussbaum has opted for a more determined analysis of basic needs. In addition, Max Neef's approach on basic needs will be presented. In contrast with the other two, Max Neef is keen on presenting a very detailed and comprehensive list of basic needs that satisfy an individual's well-being. The chapter will conclude by presenting three new approaches that try to merge elements of all three aforementioned approaches while they try to integrate sustainability explicitly or implicitly.

Chapter 5 introduces the Ecosystem Services Framework. Firstly, a brief presentation of the Ecosystem Services Framework will be presented. More specifically, the basic characteristics, purpose, categorization and development throughout the last fifteen years will be presented. The focus will be basically on how sustainability is expressed in the Framework and how well-being is assessed. For that reason, the application of the ES Framework will be presented. Secondly, a specific trait of the ES Framework will be analysed. This trait is the concept of justice. Expressed in "well-being" terms, one will look at how the application of ES ensures well-being and how these can ensure the satisfaction of the "meta-capability" expressed in the previous chapter.

Chapter 6 presents the first case study. The chapter begins with a short introduction of the Water Framework Directive. Afterwards, the basic theoretical framework will be presented. The main part of the chapter is dedicated to a thorough economic valuation of water ecosystem services in the Water Districts of Central and Western Macedonia. The primary research will be conducted within the frame of composing the Water Basin Management Plans for the aforementioned water districts and more specifically the economic valuation and cost recovery ratio for all water uses. The next step is to use those values so to assess the value of specific water-related ecosystem services. This analysis is the first of its kind Greece.

Chapter 7 presents the second case study. The main part of the chapter is dedicated to a thorough analysis of water-energy nexus and the multi-faceted aspects for that relationship. Focus of the analysis will be the United States of America (USA), where the concept has been examined in detail. More specifically, two basic categories will be investigated: water for energy and energy for water. Furthermore, an aspect of the energy-water nexus will be described. This concerns water desalination. Despite the fact, that water desalination has currently a very marginal role in the water-energy nexus, it is expected that it will be of emerging importance in the near future.

Chapter 2: The Notion of Sustainability

2 The Notion of Sustainability

Sustainable development has been defined as the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. (WCED, 1987).

This is one the most used definitions for sustainable development. Nevertheless, the concept of sustainable development was not born with the so- called “Brundtland Report” in 1987. The roots of sustainable development and sustainability date back to the 17th century at which time the term was coined (Grober, 2007). Interestingly, the term was operationally used in the forestry sector and is the dominating doctrine for two centuries now. But it is after the post war era, where the term escaped from the restricting limits of the forestry discipline and gained a more ample use. Its definition as it is widely known can be seen the acceptance of the term as policy goal and its successful introduction to the policy agenda, waiting to be implemented.

Firstly, the historical roots of the term sustainability and sustainable development will be presented. Secondly, the process of introducing the term in the policy agenda will be described. Thirdly, the evolution and implementation of the notion of sustainable development during the last 20 years, since the publication of the Brundtland Commission in 1987 will be analysed.

Chapter 2: The Notion of Sustainability

2.1 The strange origins of sustainability

The contemporary conception of sustainability is strongly related with nature, ecosystems and their preservation and their conservation. The achievement of sustainability is seen as a means for preserving a safe operating space for the human race (Rockström et al., 2009). Such a direct interconnection was not so blatant at the initial point of the notion's conception. Surely, sustainability was also then seen as a means to an end but that was completely different and to a certain rate peculiar, from a contemporary point of view. However, it should not be undermined that even at its initiating phase, the genitors of sustainability were conscious of the long- term vision of sustainability, a view that is also shared in our days.

Necessity was the primary cause of the emergence of a primitive notion of sustainability. More specifically, it was the necessity of the English Navy to expand and conquer the seas. For that reason, the expansion of the English fleet was a prerogative. Nevertheless, wood was the primary component for ship construction. In addition, the growing population on the island had as a consequence the increasing demand for firewood and wood as a construction material. These factors, along with the Civil War (1642- 1651) contributed to the massive deforestation, a fact that alarmed the Commissioners of the British Navy (Gruber, 2002). For that reason, the Commissioners attended the newly founded research institution of Royal Society for assistance and advice concerning the prospective scarcity of timber, which could impede the dominance of the British Navy. The Member of the Society that was actively engaged to the Navy's plea was John Evelyn (1620-1720), a courtier, close to King Charles II., a garden designer, entrepreneur, bee-keeper, connoisseur of the fine arts, author of books with a wide range of topics. His advice was finally presented on 16 February 1664 to the King, the Royal Society and to the public with his book "*Sylva or a Discourse of Forest Trees and the Propagation of Timber in His Majesties Dominions*" (Grober, 2007). The book ended up being a 17th century best seller and Evelyn tried to recommend measures so as to tackle with the problem of timber scarcity. However, his presentation was not constrained to mere recommendations. Beyond the analysis that included a comprehensive survey of dentrological state-of-the-art knowledge and charged bias for monarchism, he calls for ecosystem conservation and forest protection (Evelyn, 1664). Even more than that, his leitmotiv was to take into consideration the interests of the future generations, i.e. intergenerational justice ("posterity" as he describes it). Each generation was "non sibi soli natus" (not born for itself), but "born for posterity" (Evelyn, 1664, p. 273). In this context, Evelyn plants the seeds for the ethics of a responsible and provident society: *"... men should perpetually be planting, that so posterity might have Trees fit for their service...which it is impossible they should have, if we thus continue to destroy our Woods, without this providential planting in their stead, and felling what we do cut down with great discretion, and regard to the future*" (Evelyn, 1664, Vol.II p. 205). Undoubtedly, Evelyn with ihis book can be seen as a progenitor of the Brundtland Report.

A similar concern was behind the second forerunner of sustainability, Jean Baptiste Colbert (1619- 1683) and "Ordonnance" of 1669. King Luis XIV, alarmed by the gradual scarcity of timber for the construction of the French fleet, which was lagging behind other national fleets, stopped timber sales from the royal forests. Colbert, the king's foremost "Domestique", the "intendant des Finances" and Secretary of the Navy, was the person behind the concept of timber supply management in a "sustainable way" (Gruber, 2007). The final draft of the "grande ordonnance forestière" entered into force in 1669 and contained a lot of details concerning the minimum age of foresters, penalties for e.g. arson as well as the introduction of foresters in charge over the private and communal forests, the reduction of grazing in the forests, the reorganization of timber sales system, the establishment of a tight control over the exploitation rights (Deveze, 1962). In contrast with Evelyn's recommendations, Colbert's ordinance was a law that was imposed on the French state. However, it did not lack any intergenerational concerns *("Il ne suffit pas d'avoir rétabli l'ordre et la discipline, si par de bons règlements on ne les assure pour en faire passer le fruit à la postérité*") (Deveze, 1962). Nevertheless, its primary rigidity and the need for a detailed description of any related provisions have led the "ordonnance" to fail after 10 years of implementation but elements such as "*bon ménage*" (good housekeeping) and "*bon usage*" (wise use) were clear connotations for sustainability (Gruber, 2007).

Hanns Carl von Carlowitz (1645- 1714) was the first that employed the term "sustainable" and established the term "sustainability" as it is used today. Hanns Carl von Carlowitz originated from a family that was in charge for generations of the forests and hunting-grounds of the reigning dynasty and spent many years abroad, witnessing the changes brought about by Evelyn and Colbert (Gruber, 2007) and got in contact with the pantheistic philosophy of Baruch Spinoza that advocated that God and nature were identical (deus sive natura)[1]. After his extensive journeys to Europe, von Carlowitz returned to his native region, Saxony, where he was appointed high-ranking official and later head of the Saxon mining administration, located in Freiberg. At that time, he published "*Sylvicultura oeconomica*" (1713). The writing of that book was triggered once more by the increasing deforestation of the Saxony that could cause, according to the author, the economic downturn of Saxony's silver mines and melting industries, which at that time constituted the basic economic sectors of the kingdom. So, once more it was the economic interest behind the necessity of implementing a policy based on sustainability. In his book, von Carlowitz criticizes the dominating doctrine of the era, i.e. the short term profit maximization. This has led to the devastation of woodlands and their replacement with agricultural fields, something that could lead in the long run to an unrepairable damage of the Saxony's forests and consequently to the decline of Saxony's economy (Carlowitz, 1713).

However, von Carlowitz is not only restricted to criticism but offers firstly practical proposals such as "*Holtzsparkünste*" (the art of saving timber) with the use of energy-saving stoves in housing and metallurgy and the improvement of the heat-isolation of buildings or suggesting "substitutes" of timber such as turf (Gruber, 2007). Secondly, he proposes strict rules concerning forest preservation forests: "*Daß man mit dem Holtz pfleglich umgehe*" (that we use timber with care) (Carlowitz, 1713, p. 87). The term "pfleglich' is – according to Carlowitz

[1] Spinoza made a distinction between empirical nature (natura naturata) and the underlying "divine" productive forces and generative energies of nature (natura naturans), eternally circulating and pulsating within "natura naturata", seeking a new balance between faith and reason.

– an old term meaning "economically", but it also presupposes the need for the renewal of the cleared forests. Therefore, he proposes a balance between renewal and cutting so that timber could be used for ever, continuously and perpetually. According to von Carlowitz, the term "pfleglich" seemed to insufficiently express the idea of using natural resources wisely and on the long run. Then, he asks himself:"wie eine sothane Conservation und Anbau des Holtzes anzustellen, daß es eine continuirliche beständige und nachhaltende Nutzung gebe" (how to achieve such conservation and growing of timber that there will be a continual, steady and sustained usage) (Carlowitz, 1713p. 105). This is where the term "nachhaltend" or "nachhaltig" appears and signals the birth of "sustainability" (Gruber, 2007).

Nevertheless, von Carlowitz not only uses the word "nachhaltig" (sustainable) but provides a detailed definition of the term, as it is employed nowadays (Gruber, 2003). More specifically, he deals with the three pillars of sustainability, i.e. ecology, economy and society. In relation to ecology, Nature is "milde" (mild) and "gütig" (kind), mater natura – Mother Nature, reflecting the philosophy of Spinoza. Concerning economy, he cites the biblical quote of "*Abad*" and "*schamar*", "*dress' and keep*" the soil (in Luther's translation, "*Bebauen und bewahren*"- cultivate and preserve), thus acknowledging the limits of natural resources exploitation and promoting natural resources exhaustion as "sinful" (Carlowitz, 1713). Finally, concerning society, he advocates the idea that everybody has a right to nourishment and subsistence, including the "*armen Untertanen*" (the poor subjects) and the "*liebe Posterität*" (dear posterity). Stability and durability of the community (intra generational equity) and responsibility for future generations (intergenerational justice) are the author's basic principles (Gruber, 2007).

The nascent term "*nachhaltend*" was elaborated and transformed from a term to a concept in the next years. "Sylvicultura oeconomica" was a compulsory reading for "Kameralisten", the central European school of mercantilism. During the 18th century, the term "*nachhaltend*" was slightly modified to "nachhaltig" and thus transformed into a well-defined concept of forestry in German speaking territories throughout Central Europe (Gruber, 2007). The concept of "Nachhaltigkeit" (sustainability) was used as a basic principle of a new scientific approach. Characteristically, in Sachsen-Weimar, Duchess Anna Amalia, initiated in 1761 the first general forest-survey of a German territorial state based explicitly on the concept of "*Nachhaltigkeit*" with a time horizon until 2050 (Gruber, 2007). As it was at its primary stages of development "*Nachhaltigkeit*" was not employed in the contemporary sense, but it considered forest preservation as its sole goal. However, scientists such as Gottlob König apart from criticizing the faulty use of "*Nachhaltigkeit*" so as to achieve the highest yield of timber, he tried to establish the idea that "*Nachhaltigkeit*" depends on the natural regenerative capacity of the ecosystems and had to include a multitude of functions i.e. that forest are not solely timber plantations (Schwartz, 1999). During the second half of 18th century, the first schools of the forestry discipline started to appear, firstly in the remoted areas of Germany, then to Scandinavia and finally to France, where the term was translated as "*produit soutenu et égal d'une forêt*". It was not until the middle of the 19th century when "Nachhaltigkeit" entered the English speaking territories with the term "*sustained yield*" (Gruber, 2007).

The notion of "*sustained yield*" entered the United States after many decades i.e. in 1900. Surely, there were some fragmented events towards that direction such as the establishment of the first national parks at Yellowstone (1872) and Yosemite (1890) or the appointment of Carl Schurz as Secretary of Interior in 1877 or Bernard F. Fernow as the first chief of the Bureau of Forestry. Both were struggling to implement the idea of "*sustained yield*" in the US forest management (Fernow was in addition a trained forester of the renowned Prussian Academy at Hannoversch-Münden). However, they could not influence the dominant policy of the time and could not create a coalition of possible supporters of that idea (Gruber, 2007). However, the successor of Fernow, Gifford Pinchot, had succeeded in bringing sustainability in the forest policy agenda. Gildford Pinchot came from a family of French descent and before his appointment as the chief of the Bureau of Forestry had extensively travelled Europe observing advanced forest management practices in Austria, Switzerland and Germany. Under the presidency of Theodore Roosevelt, he established the Forest Service and in 1905 published a manual entitled "*The Use of the National Forest Reserves*". There, he introduced the term "*wise use*" that employed it as its leitmotiv. He defines "*wise use*" as "*The prime object of the forest reserves […]. While the forest and its dependent interests must be made permanent and safe by preventing overcutting or injury to young growth, every reasonable effort will be made to satisfy legitimate demands*" (Pinchot, 1998). The concept of "*wise use*" was part of the Conservation movement that Roosevelt and Pinchot advocated and had its origins in the classical utilitarianism of Jeremy Bentham (1748 – 1832) and John Stuart Mill (1806 –1873). Their basic concept "greatest good for the greatest number" was modified by Pinchot by adding the dimension of time, thus transforming it into the term "*wise use*" (the use of natural resources for the greatest good of the greatest number for the longest time) (Pinchot, 1998). "Wise use" as an adaptation of the European "Nachhaltigkeit" was not implemented without any resistance. From the one side, there were the American industrialists that had overexploited the American forests and from the other side of wilderness supporters that advocated the conservation of a pristine nature (Gruber, 2007). Nevertheless, even with strong resistance, the idea re- emerged in the early 1930's as part of Franklin Roosevelt's "New Deal" that included the struggle against the erosion of soils (dustbowl) or the establishment of the Civilian Conservation Corps, which engaged millions of young unemployed with reforestation and restoration of nature (Gruber, 2007). In addition, the "*wise use*" influenced Aldo Leopold (1887 – 1948), so as to write his book "*Land ethics*". The book has been hailed as a landmark of the American conservation movement and constituted the basis of the 1960's rise of the ecological movement.

2.2 The post-war period I: Bringing sustainability into the policy agenda (60's)

After World War II, sustainable development tried to breach its confined application in a certain discipline. Nevertheless, it was not presented as a goal in itself. Firstly it was the presentation of or promotion of certain environmental problems that facilitated the information of the general public. However, environmental problems did not appear in an instance.

Vogler (in Beck, 1998) emphasises that environmental problems cannot be perceived as such until the time the society and the related institutions acknowledge it as a problem. In final analysis, it is people and their activities that endanger Earth. Environmental threats are not caused by the introduction of some “exotic” and/ or “alien” substances but to human activities (Beck, 1998).

After Waldo’s book “*Land Ethics*”, it was Rachel Carson’s “*Silent Spring*” that defined the “turning point” in our understanding as far as the interconnections among the environment, the economy and social well-being are concerned (IISD, 2012). Published in 1962, the book described the population decline caused by the insecticide DDT. Among others, Carson criticized the attempts to control and even manipulate nature through the use of synthetic substances (Carson, 1962). Carson’s “tour-de-force” was that her book triggered a series of actions and gave birth to the environmental movement (expressed as Deep ecology movement). In addition, Carson’s contribution led to the formation of the Environmental Defense Fund, which pursued legal solutions for environmental damages.

The second landmark concerning the introduction of sustainable development in to the policy arena is the publication of Paul Ehrlich’s “*The Population Bomb*” in 1968. The book signals the emergence of the so-called “neo-Malthusian” concepts as it advocates the accelerated population growth thus having an impact on food security i.e. endangering it (Ehrlich, 1968). Leaving aside the criticism on the content of the book, one specific element in Ehrlich’s analysis is crucial as it paves the way to the introduction of sustainable development: the acknowledgement of limits.

One could advocate that these two characteristic examples underline that environmental policy and more specifically sustainable development are gradually gaining in importance and are slowly being introduced to the policy agenda. More specifically, looking from the view of political science, one could say that environmental policy is the beginning of the so-called policy cycle.

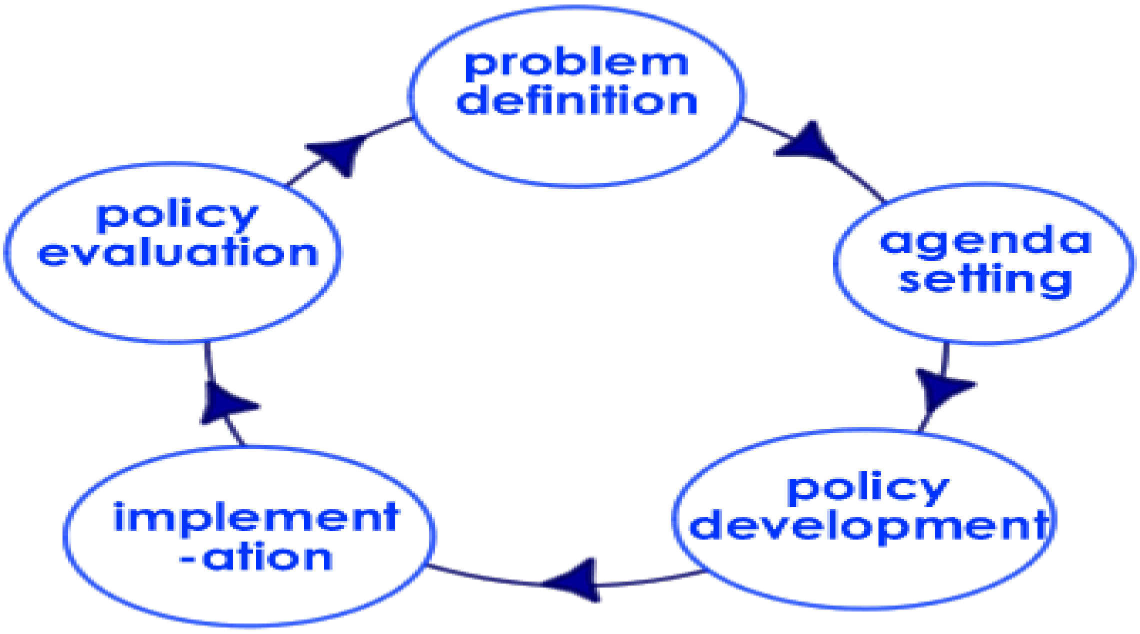

Figure 2-1: Policy cycle and its stages.

At the end of the 60's environmental protection and sustainable development are located at the first stage of the policy cycle i.e. the problem definition. And as it was previously, it is at that time when environmental problems are received as such, firstly from some engaged stakeholders and as it will be presented afterwards by institutions.

The next important landmark for sustainable development is the approval of the National Environmental Policy Act (NEPA) in 1969. NEPA established the first policy towards sustainable development (EPA website). More specifically, NEPA's purpose is

"to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfil the social, economic, and other requirements of present and future generations of Americans" (Sec. 101 [42 USC § 4331]).

NEPA aimed at enacting a nationwide environmental policy so as to enlarge the federal agencies' basic mandates as well as establishing the mechanisms and the procedures for the efficient implementation of such a novel policy (Anderson, 2013). At the time of its approval, the Congress was not still conscious about the uniqueness of NEAP and could not realize the magnitude of the changes this act was able to bring about not only on a national (Anderson, 2013) but also on an international level.

In addition, one year after NEPA entered into force the U.S. Environmental Protection Agency (EPA) was established. EPA was an independent agency in the executive branch of the federal government and has been charged responsible for carrying out federal laws to protect the environment, so as to improve and preserve the quality of the national and global environment (EPA website).

NEPA constitutes the first necessary step in order to sustainable development enter the policy cycle and can be finally introduced in the institutional dimension of politics i.e. polity (bpb, 1994). The other dimensions of politics i.e. politics (procedural dimension) and policy (normative substance-based dimension) will be promptly presented.

The three dimensions of politics:

[…] "First of all politics has ... an institutional dimension, which is determined by the constitution, the legal system and tradition. The principles which serve in forming a political will are also channeled through institutions: elections, fundamental rights, freedom of opinion, parties and associations. ... the room for manoeuvre and action is pegged out by the institutions. The word used for this institutional dimension of the political process is polity.

Politics also has a second normative, substance-based dimension, which refers to the political objectives, tasks and issues. The way in which politics is structured and the way in which it sets out to fulfill its tasks is dependent on interests. ... (This means) that the room for manoeuvre in terms of structuring political substance is filled with the seeds of conflict. This substance-based political dimension is referred to as policy.

And thirdly, politics has a procedural dimension, which aims to mediate interests through conflict and consensus. Forming a political will or opinion is a continuous process and cannot be understood by studying the institutional or substantive dimensions in isolation. ... The third dimension of the political process is known as politics."

When taken together, all three of these dimensions - the institutional, the normative substance-based and the procedural process - conspire to make up that which can be defined as politics."

Source: BpB, 1994 : Politikdidaktik kurzgefasst. Planungsfragen für den Politikunterricht, , series Bd. 326, Bonn 1994; p. 20-21

Box 2-1: *The three dimensions of politics*

2.3 The post- war period II: Providing the scientific basis for sustainable development (70's)

With the boost gained in the previous decade, the environmentalist movement continues to adopt at the beginning of the 70's a radical position. However, the 70's can be described as the decade of "environmentalism" (Hajer, 2006) or it can even be argued that the environmental movement was at that time at the age of "puberty". In other words, the 70's were the crucial decade, where environmentalist ideas demanded, gained support and were finally integrated in the existing political and institutional structures.

Crucial landmarks for that decade were the publications of a series of reports that adopted a certain common language and a certain leitmotiv. Those are the "*Limits to Growth*", the "*Blueprint for survival*" and finally the book "*Small is beautiful*".

"*Limits to Growth*" was a report prepared by Meadows et al. (1972) for the Club of Rome, as it is characteristically underlined (Hajer, 1994). "*Limits to Growth*" was prepared by a group of established experts from the Massachusetts Institute of Technology (M.I.T.) and the report was merely a scenario analysis that tried to answer the question: *"what will happen over the next 130 years if humanity decides to follow certain policies?"*(Randers, 2012; p.xiii). By using a computer model (World3) and echoing neo- Malthusian assumptions the team investigated the consequences of five interrelated trends: accelerating industrialization, rapid population growth, widespread malnutrition, depletion of non-renewable resources, deteriorating environment.

The report concluded with an apocalyptic and dystopian message, by emphasising the current model of growth is not sustainable and apart from that the existing power structures are not capable of meeting the new global challenges (O' Riordan 1983: pp.60; Paehlke, 1989:pp.41). Surely, the report was criticized as it brought an apocalyptic message with scientific justification, and many renowned scientists urged to decompose the integrity of the report as far as the assumptions or the data quality is concerned (Bardi, 2011; p.13). However, the content and the integrity of the report, "*Limits to Growth*" underlined a very important conclusion: that environmental problems should be seen as global issues (Hajer, 1994) necessitating global solutions. Even that remark was criticized as it was accused the report was promoting an implicit political agenda. However, one should note that "*Limits to Growth*" was one of the off springs of the 60's environmentalist movement and echoed the general ideological climate of that period (O' Riordan 1983: pp.60).

"*Limits to Growth*", in contrast with the other reports and books of that decade was characterized by a particular trait, which was its focus on problem definition (s. Figure 2-1) and as Hajer (1994: p.83) successfully explains:

"If you define a problem, you partly define its solution, while you do not immediately run the risk of being accused of using a problem to further your own goals"

The second report was the "*Blueprint for survival*" composed by Goldsmith and Allen (The Ecologist, 1972). Just like the "Limits to Growth", the report underlined that the environmental crisis was serious and needed to be immediately addressed. Nevertheless, authors of the "*Blueprint for survival*" followed another more radical narrative. Apart from defining the problem, Goldsmith and Allen (The Ecologist, 1972) presented a complete outline of the environmentalist strategy that included much more than strict environmental matters. The report criticized the existing mode of production as well as the existing capital labour relations and advocated the development of relatively closed communities working with intermediate technologies (The Ecologist, 1972). The report received widespread support from scientists (34 scientists endorsed its principles and 180 more supported the report) and was in final analysis considered as a romanticist critique of the modern society. Much more than the "Limits to Growth" it supported the "*creation of an anti- technocratic, decentralized utopia but at the same time drew on cybernetics to illustrate the urgency of its call and relied on comprehensive planning techniques to bring about the utopia of self-sufficiency*" (Hajer, 1994: p.85).

The third landmark was the publication of the book "Small is beautiful" by British economist E. F. Schumacher, Chief Economic Advisor to the UK National Coal Board for two decades. The book following the leitmotiv of the two aforementioned reports exercised critique on the existing western economic thinking and warned that the continuation of such practices contrasted heavily the mainstream approach of limits (Schumacher, 1973). Schumacher (1973) rejected the large scale thinking and supported a more so-to-say "human scale approach", nearer and friendlier to human society and its members (Schumacher, 1973).

As it was noted earlier, the first two reports were the off springs of the 60's radical movement of environmentalism and echoed its critique of the current process of modernization and rationalization. Apart from that, radical environmentalism emphasized a period of economic growth the price of success of that specific process (Offe, 1985). Based on that, the novelty of "Limits to Growth" was the fact that it was the product of that system and structure that was thought to be the problem. Beyond that, "Limits to Growth" attempted to find appropriate technocratic answers with an emphasis on hierarchical management and the continuation of routinized practices (Hajer, 1994). Consequently, "Limits to Growth" attempted to "speak" in the language of the existing structures, contrary to the "Blueprint for Survival". Nevertheless, both reports were directed to two different sets of actors that were overlapping.

"Limits to Growth" can be characterized as more influential in comparison to its counterparts, as it integrated and influenced the existing power structures. Apart from that, the trajectory of the environmental policy in the 80's, with the emergence of ecological modernisation, supports the previous claim. Nevertheless, there were also a number of situative framework conditions (Jänicke, 2002) that contributed to that development (Hajer, 1994).

The streamlining and rationalization of the radical ecological movement and consequently to its adaptation as ecological modernization can be attributed to 4 reasons (Hajer, 1994).

a) Radical environmentalism and its prerogatives were caught up by the economic recession. The end of the 70's signalled the end of an era that was characterized by continuous economic growth. Into that structure, the principles and the demands of the radical ecological movement could be seen as foremost priorities of a well-off Western society. Nevertheless, the economic recession obstructed the realisation of those principles, as policy agenda focused at including other policy priorities, more critical in its nature as they were defined by the related stakeholders, leaving ecological demands on the sidelines.
b) The activity of a long array of professionals that were engaged in the promotion of environmental policy related demands and its "environmental movement as a social power" realized that confrontation as a means of imposing their own agenda was not sufficient anymore. Consequently, there was a need for a re-design of the strategies pursued by the ecological movement and to a re-orientation to a more strategic and efficient direction.

c) Further issues not so clear such as nuclear power have emerged. This was the case for the newly emerged problems of acid rain and the diminishing ozone layer. However, those problems have been perceived as "*a promising basis for further extension of the social influence of the environmental movement*". This could be realised through the publicity and the promotion of those environmental problems by the NGOs, without promoting an alternative lifestyle and a radical counter culture but by simply presenting the problems emerged due to the industrial practices in place.

d) The landmarks of the 70's i.e. the publication of the "Limits to Growth", initiated an alternative discourse, parallel to the main discourse of the environmental movement (confrontation with the existing practices, proposition of an alternative lifestyle). Despite the fact that this discourse was less active and less visible, it proved to be more efficient, as it brought certain environmental demands in the policy agenda of certain institutions. The mediating role was played mainly by secondary policy institutes such as the OECD and the UNEP that initiated the study of environmental problems and proposed the design of appropriate policy instruments. This constituted the first regulatory basis for the introduction of environmental policies in countries. However, those institutions did not operate according to the "traditional image of Leviathan", imposing an environmental policy instrument from above. On the contrary, those institutions aimed at promoting their rationale by hailing the efficiency and success of those environmental policies.

2.4 The emergence of ecological modernization and the naissance of "Sustainable development"

The concept of ecological modernisation was primarily initiated by Professor Martin Jänicke at the Freie Universität Berlin in the early 80's. Nevertheless, it was not until the early 90's that his approach gained prominence outside the German speaking academic world (Buttel, 2000). During the 90's the concept gained prominence and was systematically employed and analysed by social scientists (Seippel, 2000).
The main target behind the formulation of the "ecological modernisation" approach was to provide an explanation concerning the intersection between "ecology and economy" (Jänicke, 1984; 2000). Modernisation can be explained in economic terms as the systematic improvement of industrial processes and products (Jänicke, 2000). Consequently, it was seen as a stage of capitalism's evolution from the so-called "*additive*" "*end-of-the-pipeline*" solutions to technically more efficient techniques and technologies that were aiming at the prevention of environmental problems ("*Vorsorgeprinzip*") (Jänicke et al., 2003).

However, as the "ecological modernisation" gained prominence as an "ex post" policy analysis tool, it was adapted by social scientists as a vehicle to interpret and analyse the policy developments in the industrialized countries' environmental policies during the 80's and the 90's (Mol and Spaargaren, 2000). The two prominent scholars have tried to build up a more comprehensive theoretical approach as far as ecological modernisation is concerned. Several debates were integrated in the scientific dialogue such as the Greening of capitalism, the rationalisation of production and consumption (Spaargaren and Mol, 1992; Mol and

Spaargaren, 2000; Spaargaren et al., 1999; Mol and Spaargaren, 1993; Spaargaren, 1996; Mol, 1995, 1997), aiming at depicting ecological modernisation as a "belief system"(Langhelle, 2000). In addition, Martin Hajer opted for a constructivist approach by using "ecological modernisation" as the current dominant discourse that dominates environmental policy from that period on (Buttel, 2000). Finally, Mol (1999) wanted to make a differentiation between the first-generation of ecological modernisation literature and the second generation literature (late 90's). While the first generation literature hypothesizes that capitalist liberal democracy has the institutional capacity to reform its impact on the natural environment, and "*that one can predict that the further development (``modernisation'') of capitalist liberal democracy would tend to result in improvement in ecological outcomes*" (Buttel, 2000). The second-generation ecological modernisation literature, by contrast, has focused on the identification of the specific processes through "which the further modernization of capitalist liberal democracies leads to (or blocks) beneficial ecological outcomes" (Mol, 1999). Here the work of Ulrich Beck's on Risk Society (1992) can be seen as an input of the analysis of the second generation.

One way or another, one can say that the process or approach of ecological modernization was the catalyst for the emergence of sustainable development as a policy in the 90's, as we move from the solution of environmental problems to its prevention (Jänicke, 2003).

As it was explained above, ecological modernization and its establishment as a policy paradigm facilitated and influenced the creation of the term "sustainable development". This was initiated in 1983, where the UN established the World Commission on Environment and Development (WCED). The Norwegian Prime Minister, Gro Harlem Brundtland was appointed Chairman of the newly founded Commission, whose aim was to investigate the multi-faceted aspects of economic growth. More specifically the Commission aspired to examine the raising concerns over "the accelerating deterioration of the human environment and natural resources and the consequences of that deterioration for economic and social development" (WCED, 1987).

The Commission finally published four years later the Report "Our Common Future" and gave birth to the most common definition of sustainable development (s. WCED, 1987:45). The Report in its twelve chapters tried to amply describe the existing state-of-affairs as far as the world is concerned. In addition, the Report articulated certain proposals concerning the way forward and more specifically it expressed the prospects and the vision of a new economic paradigm. This new economic paradigm should be based on the convergence between economic development, social equity and environmental protection (Drexhage and Murphy, 2010).

The definition of sustainable development was characterised and to some extent criticised by its vagueness. Nevertheless, this vagueness contributed to its acceptance by the majority of the stakeholders engaged. As it will be described later, its unclear message resulted in the adaptation of its message according each one's views and aims. This is why it can be advocated that the definition of sustainable development was produced as an "alibi" for the continuation of the existing economic model. Without exaggerating, one should note that there beyond the hundreds of interpretations of sustainable development a number of basic principles can be crystalized (Drexhage and Murphy, 2010):

- Equity and fairness: improvement of the living conditions of the world's poorest while decisions should take into account the rights of future generations;
- Precautionary principle as the guiding principle of all future policies and;
- Recognition of the independent nature along with the complex interconnection of the three pillars of sustainability, i.e. society, environment and economy.

The naissance of sustainable development as a concept marked a new period as far as the implementation of environmental and other policies are concerned. In contrast with the previous efforts, "Our Common Future" succeeded in being integrated in the policy agenda and by using the term "sustainable development, it has succeeded in being upgraded as a "buzzword" that dominated policy dialogue.

2.5 The United Nations Conference on Environment and Development: Streamlining sustainable development

As the term "sustainable development" acquired an acceptable definition, the next steps concern the integration of the sustainable into global and national policy agenda and its adaptation to the interests of the dominant stakeholders. Surely, sustainable development was interpreted differently from each particular actor and spawned a number of different approaches and interpretations.

2.5.1 The vagueness of sustainable development

The definition of sustainable development as a concept from a scientific perspective paved the way for the introduction of the term in a policy context. This is where sustainable development enters into the politics arena, where conflicted and interrelated interests struggle to impose their interpretation of sustainability. The United Nations Conference on Environment and Development (UNCED) took place in 1992 in Rio and constituted the third so-called "mega conference" (after Stockholm and Nairobi in 1982), a term coined by Seyfang (2003), showing its unique character in comparison with other summits and conferences. More specifically, "mega conferences" such as that in Rio, were addressing human development and its correlation to the environment as a whole. Apart from that, they take "*a broader overview of complex environment and development issues over a longer time frame, than is normal in national or regional policy negotiation"* (Seyfang, 2003;p.224).

UNCED was an unprecedented event as 176 national delegation attended the conference while in parallel, more than 30,000 NGO representatives participated to the Global Forum. Products of UNCED were the following agreements (Connely and Smith, 2006):

- Rio Declaration
- Agenda 21
- Declaration on Forest Principles
- Convention on Climate Change

- Convention on Biological Diversity

The last two agreements were basically the result of separate processes that were afterwards integrated in the Rio Declaration.

The Rio Declaration was merely a repetition of the continuous debate that has already started in Stockholm in 1972 and this was the "*North and South*" debate. As this is beyond the scope of the thesis a more detailed overview of that matter will not be described. So, the Rio Declaration designed a set of guiding principles based on which national governments and international organisations should implement their environmental policies. There is for example an urge to adopt the so-called "*polluter-pays-principle*" as well as the "precautionary principle". Additionally, it underlined the need for increased democratic participation and for an environmental impact assessment of development schemes (UNCED, 1992). Interestingly, one of the hallmarks of the Rio Declaration was the Principle 7, with which for the first time, "common but differentiated responsibilities" of states were acknowledged. This meant in other words that industrialised countries of the North took the responsibility for the existing environmental conditions (Connely and Smith, 2003). The other product of UNCED was the adoption of Agenda 21, an ambitious text that aimed to reconcile the need for development along with environmental protection. The final text was published long after the end of UNCED and it contains a number of contradictory points (Connely and Smith, 2003).

It can be said that from a certain point of view, UNCED was a disappointment with little in the way of notable progress. A number of crucial policy issues were not resolved. It was blatant that northern industrialised countries succeeded in imposing their views (Chaterjee and Finger, 1994) and their "storylines" as Hajer would have put it on the global policy agenda. Specific issues such as the link between poverty and development or even the control of Transnational Corporation (TNCs) were not discussed (Thomas, 1993). Apart from that financial assistance to developing countries also remained open. Such issues remained unresolved as TNCs and industrialised states such as the USA exercised their power, financially and politically so as the "status quo" can remain unaltered (Porter and Brown, 1996; pp.117-118). Even the Vatican succeeded in abolishing any provision and reference to population control. In the end, the actors who were in more advantageous position in the policy arena succeeded in imposing their own view as far as sustainable development is concerned. In other words, the existing institutional and economic structure i.e. capitalist market economy was approved and was seen as the solution for the implementation of sustainable development in the future. However, it should be said that this was an expected outcome and the achievements of UNCED should not be undermined. Apart from the achievement mentioned above, UNCED also eased the participation and engagement of NGOs to such "mega conferences" and forged the communication between Northern and Southern groups (Chaterjee and Finger, 1994).

2.6 The United Nations World Summit on Sustainable Development (WSSD): Further down the spiral

On 26 August 2002, more than 22,000 people attended in Johannesburg, South Africa the United Nations World Summit on Sustainable Development (WSSD). Its main aim was to discuss how much progress had been made since the Earth Summit in Rio in 1992 and plan further action for the future. The world's leaders were accompanied by 10,000 delegates, 8000 representatives of major groups and 4000 members of the media (UN, 2002). WSSD marked the 30th anniversary of the United Nations Conference on the Human Environment (UNCHE) which took place in Stockholm, Sweden in 1972, and the10th anniversary of the United Nations Conference on Environment and Development (UNCED) (also known as the Earth Summit) which took place in Rio de Janeiro, Brazil in 1992. The 2002 summit is also informally known as "Rio+10".

Expectations for the WSSD were high. A survey of experts in environment and development carried out by Najam et al. (2002) found that while respondents were hoping for a progress, despite the fact that they did not anticipate that WSSD would have the same impact as UNCED,. However, there was unease because it was felt that the issues which really counted—consumption patterns in the north, international trade, for example—would once more not be addressed. Apart from that, the anticipated nonattendance of the USA's President Bush threatened to undermine the political credibility and significance of the summit altogether (Pearce, 2002).

Reactions to the WSSD were mixed. Government delegates such as Margaret Beckett (UK's Minister for Environment, Food and Rural Affairs) described the summit's outcomes as 'truly remarkable' (Beckett, 2002), fuelling an outraging response by WWF wondering *"which summit did Beckett attend?"* and accusing her of living in fairyland (ENDS, 2002: p. 9). This echoed the NGOs' reaction to the summit. In many ways, the WSSD was a lost opportunity for progress—despite the enormous amount of time and money spent on preparations, and a multilateral institutional framework for articulating and developing sustainability, governments lacked the political will to adopt ambitious action plans (Seyfang, 2002). The cynical undermining of the UN and the Kyoto Protocol by the USA, and the lack of coherence among other nations, simply highlighted the contempt of industrialised nations towards WSSD.

Nevertheless, one should not undermine completely the positive outcomes of WSSD. One great achievement was the explicit acknowledgement of social development-in addition to economic development and environmental protection-as a core component in the Johannesburg Declaration's definition of sustainable development (Osofsky, 2003) promoting the third pillar of sustainable development to an equal with the other two. Again, the sensitive policy issue of North South relations was not touched and it was substituted with the need of promoting public private partnerships in developing countries and in specific sector such as water and sanitation (Ostrofksy, 2003). Apart from that, the importance of civil society was once more emphasized: citizen's groups can network and share ideas and experiences at these summits, and return inspired to drive forward local actions for sustainability, with or without the leadership of their policy makers (Seyfang, 2003). Despite the disappointment by how little concrete action was achieved on the policy level by heads of state, those small policy gains should not be really undermined, and particularly the widening of involvement by ordinary people and the broadened governance this represents.

All in all, Johannesburg was also the proof that the term "sustainable development" had gained policy acceptance. Even though some argued that the term had lost its "edge" and was mostly being used rhetorically, the fact remained that it had also become a political necessity. At best, Johannesburg was viewed as a chance to advance the agenda that had been set by Rio; at the very least, it offered the opportunity *"to keep the Rio agenda alive"* (Sibley, 2007)

2.7 The United Nations Conference on Sustainable Development (UNCSD)

The United Nations Conference on Sustainable Development (UNCSD), also known as Rio 2012, Rio+20, or Earth Summit 2012 was the third international conference on sustainable development aimed at reconciling the economic and environmental goals of the global community. Hosted by Brazil in Rio de Janeiro from 13 to 22 June 2012, Rio+20 was a 20-year follow-up to the 1992 Earth Summit / United Nations Conference on Environment and Development (UNCED) held in the same city, and the 10th anniversary of the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg (UN, 2012a).

The ten day mega-summit, which culminated in a three-day high-level UN conference, was organized by the United Nations Department of Economic and Social Affairs and included participation from 192 UN member states, among them 57 Heads of State and 31 Heads of Government, private sector companies, NGOs and other groups. It was intended to be a high-level conference, including heads of state and government or other representatives and resulting in a focused political document designed to shape global environmental policy.

The primary result of the conference was the nonbinding 49-page document, "*The Future We Want*". The heads of state of the 192 governments renewed their political commitment to sustainable development and declared their commitment to the promotion of a sustainable future (UN, 2012b). More or less, the document largely reaffirms previous action plans like Agenda 21.

Additionally, "The Future We Want" supports the design of Sustainable Development Goals (SDGs), a set of measurable targets aimed at measuring and supporting sustainable development on a global level. The initial thought behind SDGs is that these will pick up where the Millennium Development Goals leave off. Consequently, such a thought aims at the critics of the MDGs, as they were advocating that these specific targets failed to address the role of the environment in development.

Apart from that, UN Environment Programme (UNEP) is promoted to be the "leading global environmental authority". For this reason eight key recommendations are defined, including, strengthening its governance through universal membership, increase of its financial resources and empowerment of its engagement in key UN coordination bodies.

Although initiated as a discussion in progress, nations agreed to design and implement alternatives to GDP. Such indicators will serve as a measure of wealth that is going to take environmental and social factors into consideration. Such an ambitious proposal can be translated in a more realistic way such as the latest effort to assess and pay for “environmental services” provided by nature, such as carbon sequestration and habitat protection.

Furthermore, it was recognised that "*fundamental changes in the way societies consume and produce are indispensable for achieving global sustainable development*.” EU officials suggest it could lead to a shift of taxes so workers pay less and polluters and landfill operators pay more.

Finally, "The Future We Want" underlines the need to return ocean stocks to sustainable levels and calls on countries to develop and implement science based management plans, while all countries committed to phase out fossil fuel subsidies.

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Chapter 3: The View from A Hill- Intergenerational Justice

3 The View from a Hill- Intergenerational Justice

This chapter is primarily dedicated to the analysis of the term intergenerational justice. The main aim of this chapter is surely not to provide an extensive analysis of the term thus presenting the historical development of the term. Neither is to make an detailed analysis of the existing different contemporary perspectives of intergenerational justice. Both are beyond the scope of the thesis and additionally it can be disorientating. This is due to the fact that the term "intergenerational justice" has been the subject of inquiry for many scientific disciplines according to their respective scientific tradition.

The chapter begins with a short introduction of the term "intergenerational justice". What is it and isn't intergenerational justice according to the latest scientific dialogue? Then, the next section will be dedicated to John Rawls and his attempt to explain and formulate a theory of intergenerational justice. The main points of his theory will be presented. It should be noted that because of John Rawls the subject of intergenerational justice was brought again to the surface, with a number of scholars expressing their opinion about his theory.

Through a "poststructuralist lens" Rawls' theory an attempt will be made to amend it to adapt to the aims of the thesis. Consequently Rawls' theory will be viewed in a way that elements from theory will be finally exploited so as sustainability can be expressed in terms of intergenerational justice. This chapter will be based on the assumption of Axel Gosseries that sustainability can be translated as a sufficientary principle.

This chapter aspires to present a more cohesive view of intergenerational justice by borrowing elements of practical philosophy, economics and sociology. This is why a mere presentation of different theories was rejected and a more selecting process was preferred.

3.1 Intergenerational Justice: a definition

The main question here is how "intergenerational justice" can be defined. A working and plain definition of the term is merely "justice between generations" (Tremmel, 2009). This of course presupposes that justice is applied to intergenerational relations and therefore past and future generations are bearers of legitimate claims and rights against present generations, "who in turn stand under correlative duties to future or past generations" (Meyer, 2008). Currently this assumption will be adopted, but its validity will be discussed further in the next chapters. Focus of "intergenerational justice" can be either temporal or even spatial, expanding from the local level to the social level (Tremmel, 2009).

The term "intergenerational justice" has been gradually gaining in importance as far as the academia is concerned. It can be also advocated that the question of justice between generations, has been thoroughly initiated since the advent of ecological consciousness, with the publication of "The Limits to Growth" (Meadows et al., 1972). Until then, the quasi natural Kantian law (Kant 1785/1968, p. 53) predominated the relations between past and future generations.

According to this

"It is still strange that the older generations seem to do their cumbersome business only for the sake of the younger generation to prepare a platform from which they can go one step further, towards the target aimed for by nature, and that only the last generations will be lucky enough to dwell in this abode built by a long row of their predecessors (albeit not deliberately), who were not able to have their share in the joy they were preparing"

This Kantian law has been rendered obsolete based on the latest scientific findings since the 70's. Consequently, one is faced with a wholly altered landscape that is obliged to describe as accurately as possible. Hence, "intergenerational justice" can be seen as the "intellectual leitmotiv" of the 21^{st} century (Tremmel, 2006).

Apart from that it will be of great interest to inquire deductively what "intergenerational justice" isn't. It is obvious that intergenerational is differentiated from "intragenerational justice" i.e. the justice between generations. "Intragenerational justice" is a more realistic approach as it concerns people belonging to the same generation. In addition, it contains a greater number of aspects which are examined under the lens of "intragenerational justice". "intragenerational justice" embodies social justice, namely the gap between the poor and the rich within a country, international justice, justice between different countries (the North South conflict belongs to that category) and gender justice (Tremmel, 2009). Based on that, one can say that "intragenerational" is equivalent to the social dimension of justice. This has obviously further implications.

Beyond the conclusion that intra- and intergenerational justice are more or less complementary notions this has another conclusion as an effect. "Intergenerational justice" is not synonymous to sustainability. Sustainability is more or less a holistic concept that embodies both intra- and intergenerational justice (Tremmel, 2003a, 2003c, 2006). More specifically, intergenerational justice concerns the economic and ecological pillar of sustainability, while the social pillar remains at the spectrum of intragenerational justice (Tremmel, 2009).

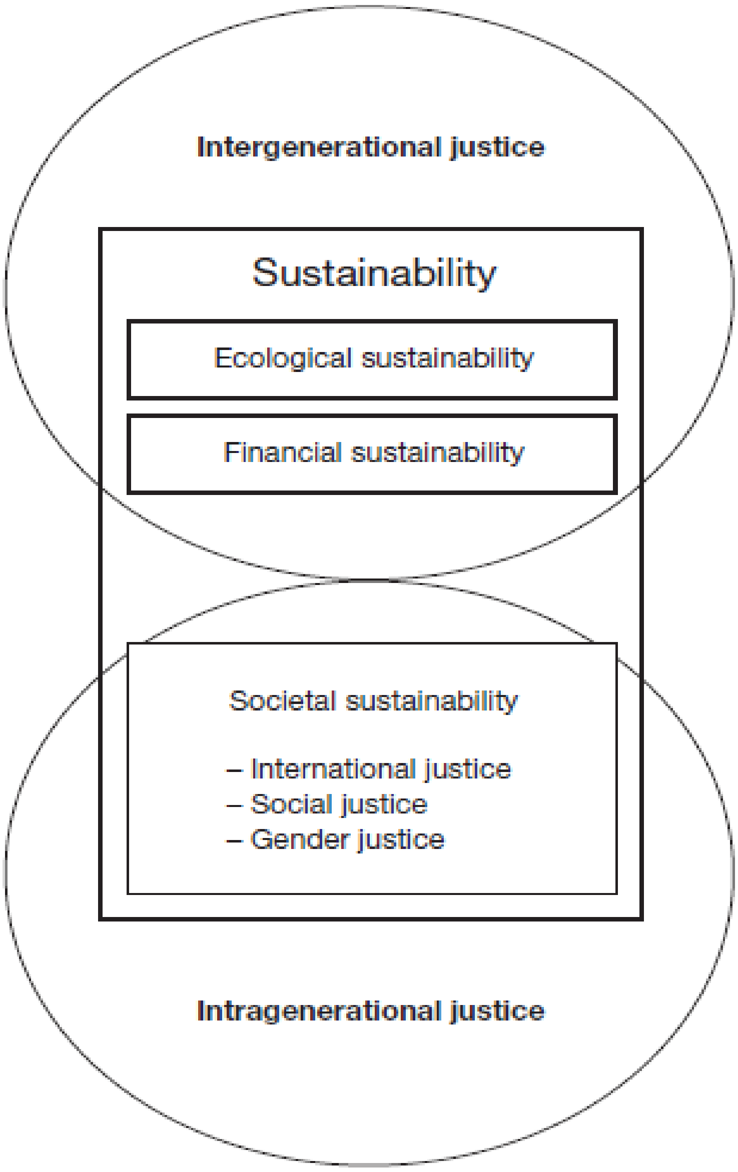

Figure 3-1: The analytical definition of sustainability. Source: Tremmel, 2009, p.8.

Tremmel's comment is very interesting as far as the development of sustainability and intergenerational justice is concerned. Predominately, the matter of sustainability is analysed by people such as economists, political scientists, biologists and ecologists as a whole, while it has focused on a certain pillar of sustainability, either the ecological or the financial, thus undermining or leaving the other pillars untouched. This is not destined to be a critique of how sustainability is perceived by the aforementioned disciplines but as a welcome addition to the existing approach concerning sustainable development.

Consequently, it should be noted that this is only one approach concerning the relation of sustainability. Other approaches consider the sustainability as an indicative category in the intergenerational justice. Such approaches will be analysed. Additionally, this specific concept can justify the analysis of intragenerational justice and for that reason the topic of intragenerational justice will be the focus of Chapter 4.

3.2 Rawls' "original position" theory

Rawls' "original position" theory is contained in his book entitled "*A Theory of Justice*" (Rawls, 1971). Rawls began to develop this theory in 1958 and no one could have predicted the aftermath of its publication. Firstly, Rawls' oeuvre was hailed as "*a welcome return to an older tradition of substantive, rather than semantic moral and political philosophy*" (Daniels, 1975), while it has spawned a series of scientific debates that are holding until now. Laslett and Fishkin (1992) characteristically claim that Rawls' chapter on intergenerational justice fuelled the composition of the majority of works focusing on intergenerational justice in 1970's and 1980's.

Rawls' theory on intergenerational justice was formulated in paragraph 44 in the chapter "*Distributive Shares*" (Rawls, 1971). Rawls' original position features two distinct traits that link his theory with the philosophical tradition, mainly of the Enlightment Era.

The first trait is the impartiality of the theory (Tremmel, 2009). Impartiality is a core trait not only of intergenerational justice but of justice in general. This is why the Ancient Greek Goddess Themis and the Roman Goddess Justitia are presented blindfolded. Barry (1989) explains "*justice as impartiality*" as the result of an agreement reached between rational people, where any bargaining power cannot be used in advantage of ameliorating one's position. Such a concept dates back to Kant (1968) with his procedural approach to justice, namely if the method is just then the outcome should also be just.

The second trait has already been mentioned above by referring to the term "agreement". This term can be translated as "a contract" and more specifically "a social contract". These positions Rawls is in line with other philosophers such as Hobbes, Locke, Rousseau, and Kant that have used a similar contractarian perspective (Freeman, 2014). The aim of the original position is establishing a social contract, in our case between generations. In contrast with its predecessors Rawls's idea of the original position does not represent the judgment of one person, however, in that it is conceived socially, as a general agreement by (representatives of all adult) members of an ongoing society.

"Rawls employs the idea of a hypothetical social contract for more general purposes than his predecessors. He aims to provide principles of justice that can be applied to determine not only the justice of political constitutions and the laws, but also the justice of social and economic arrangements in the distribution of income and wealth, as well as educational and work opportunities, powers and positions of office and responsibility" (Freeman, 2014).

So as to ensure the robustness of his hypothetical social structure, Rawls employs one of his first novelties of his theory, i.e. the veil of ignorance.

3.2.1 The veil of ignorance and the "maximin principle"

In his hypothetical social structure Rawls employs the concept of "veil of ignorance". This is merely an ingenuous invention so as to redefine the initial situation (Freeman, 2014) where representatives of all generations are participating. The main function of the "*veil of ignorance*" is to put the representatives of all generations in a situation of "*choice*" and not of "*negotiation*". As Rawls explains:

"First of all, no one knows his place in society, his class position or social status; nor does he know his fortune in the distribution of natural assets and abilities, his intelligence and strength, and the like. Nor, again, does anyone know his conception of the good, the particulars of his rational plan of life, or even the special features of his psychology such as his aversion to risk or liability to optimism or pessimism." (Rawls, 1971, p.137).

This means that parties cannot have any information about themselves, about one another, and even about their society and its history. Rawls's original position is an initial situation where the parties cannot have access to information that enables them to tailor principles of justice according to their personal circumstances. Apart from that, this "*veil of ignorance*" deprives the parties of all knowledge of particular facts about themselves, about one another, and even about their society and its history (Freeman, 2014).

Nevertheless, parties to the original position cannot be simply "tabula rasa". They should know some primary facts, based on which they can make their decision. This is why Rawls equips parties with certain traits that will enable them to make a decision. In other words, parties to the original position have basic knowledge of the political affairs as well as the principles of economics. Furthermore, they know the basis of social organization and the laws of human psychology (Rawls, 1971). Finally, there is one special hypothesis of the "original position" that will be employed further below:

"*Finally, there is the condition of moderate scarcity understood to cover a wide range of situations. Natural and other resources are not so abundant that schemes of cooperation become superfluous, nor are conditions so harsh that fruitful ventures must inevitably break down. While mutually advantageous arrangements are feasible, the benefits they yield fall short of the demands men put forward."* (Rawls, 1971, p.127)

In addition, Rawls ingenuously assumes that parties in the original position are in no way altruists and must act as if the participants take no interest in one another's interest, i.e. "*mutually disinterested*" (Rawls, 1971). Nevertheless, this does not mean that they are generally self-interested or selfish persons, indifferent to the welfare of others. Most people are concerned, not just with their own happiness or welfare, but with that of others as well, and have all kinds of commitments to others, including other regarding and beneficent purposes, that are part of their conception of the good. But in the original position itself the parties are not altruistically motivated to benefit each other, in their capacity as contracting parties (Freeman, 2014).

After the initial setting has been adequately described, parties to the “original position” are gathered to take the decision about their generation’s share. Apart from their personal features their decision should be guided by a so-called “*maximin*” principle, as each participant is endangered to end up at the bottom of the society once the “veil of ignorance” has been lifted (Rawls, 1971). The “maximin principle” can be described as the minimization of the minimal, namely the worst possible distributional situation.

Founding their decision on the “maximin principle, parties to the original position will select what he calls the “*conception of justice as fairness*”(Wolf, 2009) as the theory best suited to protect their rights and interests. This conception of justice includes two “moderately egalitarian” principles (Tremmel, 2009). The first principle, the “*equal liberty principle*”, assumes that each person is entitled to have an equal right to the most extensive total system of equal basic liberties compatible with a similar system for all. This is lexically prior to the second principle, which governs social and economic inequalities. This second principle is comprised of two sub-principles: the “*open offices’ principle*”, which describes that social and economic inequalities must be attached to offices and positions open to all under conditions of fair equality of opportunity, and the “*difference principle*” which specifies that social and economic inequalities must be organized so that they are maximally advantageous to the worst off members of society. Rawls argues that the equal liberty principle must be lexically prior to equal opportunity (the open offices principle) which is itself prior to the difference principle (Wolf, 2009).

After deciding on the ratio each party is obliged to leave to the next generation and how much should the past generation be willing to give to the present generation, Rawls focuses his attention on the means of achieving this “just” result. Here, he employs the “just savings principles”. According to that principle, two stages of development are distinguished: the accumulation and the steady state (Gosseries, 2001). During the first stage, a generation is obliged to save so as to secure justice for later generations. Just institutions protect basic rights and liberties, presumed by the “equal liberty principle”, and to secure fair equality of opportunity and distributive justice as required by the second principle of justice (Gosseries, 2001; Rawls, 2001). During the second stage the current generation is obliged to leave to the next generation as much as was bequeathed to them. There is no need for further accumulation, just a necessity to preserve the existing stock (Wolf, 2009). Rawls cites:

“The purpose of a just (real) savings principle is to establish (reasonably) just institutions for a free constitutional democratic society (or any well-ordered society) and to secure a social world that makes possible a worthwhile life for all its citizens. Accordingly, savings may stop once just (or decent) basic institutions have been established. At this point, real saving may fall to zero; and existing stock only needs to be maintained or replaced, and non-renewable resources carefully husbanded for future use as appropriate” (Rawls, 1999).

This ideal hypothetical structure has obviously a number of specific disadvantages. Especially to environmental scientists and economists, many underlying assumptions are a priori erroneous. Characteristically, if one focuses clearly on the “two stage” societal development, a zero growth population growth is implicitly assumed. This does not surely corresponds to the reality of the ascending population growth rate and the question "Which is the "*just saving*" ratio under such a situation?" remains. Furthermore, further environmental aspects are taken into consideration. Despite the fact that a moderate scarcity is assumed, Rawls adopts an optimistic vision that technological advances can compensate for the loss of natural capital (Birnbacher, 1977). His view more or less conforms to the standard models of economic growth (s. Solow, 1974) and consequently leaves this topic without further analysis.

The non- identity problem:

[…] "The 'non-identity thesis' reads as follows: not only do our present actions affect the conditions of life of future persons, they also affect which people (if any) will exist. We might say that the trouble with individual future persons is not that they do not exist yet, it is that they might not exist at all (Kavka, 1978). The same action to alter the conditions of distant future life changes the roster of individuals who exist in the distant future; this is the genetic case of 'disappearing victims' and of 'disappearing beneficiaries' (Partridge, 2007).

The non-identity problem has been the center of attention for more than two decades. During that time three "*convincing*" arguments against the non-identity problem can be articulated:

- ***The 'your neighbor's children' argument**: Distinguishing collective actions of a whole generation (political programmes) from actions of individuals reduces the scope of the 'non-identity problem' enormously,*
- ***The 'butterfly-effect' argument**: Because of an action by a present agent, a future individual came into existence. This action cannot have harmed this person if without it she would never have existed.*
- ***The 'no-difference view':** each currently existing person has died and been reborn innumerable times prior to this life and will be reborn many times in the future. When a new human body is formed, a new person is not created. Rather, an already existing person is reborn.*

To sum things up, it can be said that the 'non-identity argument' is an interesting theoretic argument that is applicable to a limited number of cases in reproductive behaviour and reproduction medicine. But it would be grossly misleading to apply it beyond this field, for instance by claiming that we cannot harm future generations by a resource-depletion policy or by driving a car instead of riding a bike. The 'non-identity problem' is not an insurmountable difficulty for a theory on generational justice.

Source: Tremmel.Joerg Chet (2009), A Theory of Intergenerational Justice, London: Earthscan series Bd. 326, Bonn 1994; p. 20-21

Box 3-1: The non-identity problem

The aforementioned topics are not the sole points of criticism as far as Rawls' theory is concerned. The most challenging question was the so called "non-identity" problem. The problem emerged from the writings of Kavka (1982), Parfit (1984) and Woodward (1987) and questions the possibility of future people having rights towards the current living people, as the existence of the former is directly correlated with decisions and actions of the latter (Meyer, 2013). More specifically, the non-identity problem focuses on the obligations one thinks to have against people who, because of our own decisions and actions, are caused both to exist and to have, unavoidably flawed existences that are flawed if those people are ever to have them at all, nevertheless worth having (Meyer, 2013). If a person's existence is unavoidably flawed, then the agent remains with two choices: either bringing no one into existence at all or bringing a different person – a non-identical but better off person – into existence in place of the theoretically flawed person. If the existence is worth having and no one else's interests are at stake, it is unclear on what ground morality would insist that the choice to bring the one person into the flawed existence is morally wrong. And apart from that, it seems that sometimes even that choice can be seen as morally wrong (Roberts, 2013, Parfit, 1987).

A prima facie, the "non-identity problem" does not seem to have any implications on the sustainability issues. Nevertheless, one of the main fields of applications of the problem is the choice of a policy that will focus or not on the depletion of non- renewable resources (Parfit, 1987). The analysis of the "non-identity problem" on the specific topic has a direct impact on the contingency of the number and specific identity of future people (Meyer, 2013). One way or another the "non-identity problem" and its solution has gradually led to a series of publications by scholars and the vast amount of literature is making it impossible to present a more concise overview of the problem as it will from a certain point exceeds the scope of the thesis.

3.3 A second reading of Rawls' "original position": Adopting a needs principle

Rawls' original position fuelled a wildfire of essays and publications concerning the subject of justice and more specifically intergenerational justice (s. English, 1997; Parfit, 1987, Koller, 2007). This ample feedback offered by various scholars was a fruitful addition to the scientific dialogue on that matter and motivated Rawls to amend to a certain extent his primary theory of intergenerational justice.

It was mentioned above that Rawls' theory can be described as "*moderately egalitarian*" (Wolf, 2009). Nevertheless, others characterize his theory as "*sufficientarian*" (Meyer, 2013). Such an assumption might appear strange to certain professionals, for example economists or biologists, as it cannot be understood how the same can have two distinct and fairly different characterizations. However, such assumptions are reasonable in the postmodern and poststructuralistic tradition of political philosophy. Postmodernist thinking follows the doctrine of Deconstruction, primarily described by Heidegger as "*Destruktion*" (Heidegger, 1927) and further elaborated by Jacques Derrida (1967). More specifically, Derrida, as well as others postmodern philosophers, advocate the variable projection of the meaning and message of critical works, the meaning in relation to the reader and the intended audience, as well as the assumptions implicit in the embodied forms of expression (Derrida, 1967). As Derrida notes:

"When I say that this phase is necessary, the word phase is perhaps not the most rigorous one. It is not a question of a chronological phase, a given moment, or a page that one day simply will be turned, in order to go on to other things. The necessity of this phase is structural; it is the necessity of an interminable analysis: the hierarchy of dual oppositions always re-establishes itself. Unlike those authors whose death does not await their demise, the time for overturning is never a dead letter" (Derrida, 1981).

This means that one is not obliged to take a specific stance on a certain subject but more or less to be a spectator of the "clash" and to analyse it.

At this point one can take Rawls' theory and describe it and give the subjective opinion on it. At this specific point, the research is not willing to characterize Rawls' theory as "egalitarian" or "sufficientarian". However, the main aim of the research incorporates some additional features on its existing theory that suffice, so the research can return to the main topic of sustainability and how that can be explained in other terms, those of "intergenerational justice". Such an amendment follows the interpretation Wolf (2009) has firstly described.

As mentioned above parties to the original position adapt their behaviour on some basic principles of justice, which according to Rawls are the primordial rules that constitute the "conception of justice as fairness". These principles are the following (Rawls, 2001):

- The "*equal liberty principle*": "*each person has the same indefensible claim to a fully adequate scheme of equal basic liberties, which scheme is compatible with the same scheme of liberties for all*"
- The second principle contains the following two sub-principles
    - The "*open offices principle*": "*social and economic inequalities [must] be attached to offices and positions open to all under conditions of fair equality of opportunity",*
    - The "*difference principle*"*: "[social and economic inequalities] are to be to the greatest benefit of the least-advantaged members of society".*

Later, Rawls intended to incorporate an additional principle in the theory of justice. Therefore, he proposed a "*needs principle*" that will be lexically prior to the other principles (Rawls, 1993).

" the first principle covering the equal basic rights and liberties may easily be preceded by a lexically prior principle requiring that citizens' basic needs be met, at least insofar as their being met is necessary for citizens to understand and to be able fruitfully to exercise [their]

rights and liberties. Certainly any such principle must be assumed in applying the first principle" (Rawls, 1993).

This addition underlines the necessity of providing a sufficient minimum to people, before all other principles of justice are to be met, and consequently the theory of justice can be characterized as "*moderately sufficientarian*" (Wolf, 2009). It should be repeated that putting the theory of justice into a specific category has no direct effect. There is already the "*difference principle*" that by definition has a so-called sufficientarian connotation. However, pointing out the hierarchy of the principles seems here to be of a special interest. A "*needs principle*" may be fully satisfied even with the existence of vast inequalities, while the "*difference principle*" will continue to generate requirements even where all needs are met. If a "*needs principle*" requires the minimisation of unmet need, then a needs principle will occasionally generate requirements inconsistent with the difference principle (Wolf, 2009).

Wolf (2009) continues his argumentation by providing four reasons why a lexical prior "*needs principle*" is a necessary amendment to the theory of justice:

- Social institutions must be defensible to any member of the society
- It reinforces and justifies in most of case the "*difference principle*"
- Satisfaction of basic needs is a precondition for the significance of the equal liberty principle and the value of the rights and liberties it guarantees.
- Meeting basic needs constitutes a primary objective from a moral point of view

Consequently a slightly amended theory of justice should incorporate a lexically prior "*needs principle*" which is formulated as the minimisation of deprivation concerning fundamental needs. In that way, one can argue that there is a more than clear view of "*sufficientarism*" in the amended "*A Theory of Justice*". Apart from that, certain terms are referred in this chapter that will be accordingly used in the next chapters. The first term that will be used is that of "*sufficientarism*" that presupposes the existence of a threshold. "Sufficientarism" was deliberately not explained in this chapter as will be used as the means of interpreting sustainability in "intergenerational justice" terms, a concept coined as "*Brundlandt's sufficientarism*" (Gosseries, 2004).

3.4 Brundtlandt's sufficientarism: Axel Gosseries' approach

Axel Gosseries (2008) in presenting a synopsis of intergenerational justice has articulated and attempted to translate "sustainability" in intergenerational justice terms. One of his basic premises and preconditions of "sustainability" expressed in terms of political philosophy is the "*indirect reciprocity*" approach. "*Indirect reciprocity*" is a useful and valuable concept at the hands of scientists willing to reason the necessity of pursuing sustainability as a policy goal. Brian Barry (1989) employs that concept. "*Indirect reciprocity*" presupposes that people are obligated to return to others what they themselves have received from them, under the hypothesis that they are able to do so (Barry, 1989). Such a premise is widely accepted and is articulated as the proverb that we do not inherit the Earth from our ancestors; we borrow It from our children (Berry and Meatyard, 1991). More specifically, the concept can be further revised as "descending reciprocity". This concept can be further broken down into two maxims. The first maxim aims to explain why we are obligated to the next generation (Wade-Benzoni, 2002). This maxim, known as justificatory maxim, obliges current generation to bequeath something to the next generation, just as the previous generation has done to them. This is surely something really different from the proverb mentioned above. In addition, there is the second maxim, namely the substantive maxim, that obliges current generation to pass on to the next a capital at least equivalent to the one it inherited from the previous one (Gosseries, 2008;2009). This maxim clearly corresponds to the notion of sustainability.

Before presenting "sustainability" as "*Brundtlands' sufficientarism*", the sufficientarism doctrine should be presented. "*Sufficientarism*" attempts to ensure a "minimal threshold" to each and every one (Gosseries, 2011) .Such a threshold is not defined arbitrarily but absolutely. In its former version, then the concept is named as "leximin egalitarianism" and resembles the Rawls' theory. In other words, in "*leximin egalitarianism*" the main preoccupation is to ameliorate the less favoured but the "*threshold*" is defined accordingly to the total sum of the aggregate welfare or well-being. However, it should be noted that as with "*sufficientarism*", "*leximin egalitarianism*" is not interested in reducing the inequalities (this concerns for classical egalitarianism) but to secure a sufficient threshold of existence to each and every one.

The most basic difference between "*sufficientarism*" and "*leximin egalitarianism*", is how the threshold is defined. This threshold is defined in absolute terms (Gosseries, 2011), without taking into consideration the relative aggregate welfare. It can be argued that "*sufficientarism*" is a capped version of "*leximin egalitarianism*" (Gosseries, 2011).

There are certain reasons why one should advocate "s*ufficientarism*" (Frankfurt, 1987; Gosseries, 2011):

- If everyone had enough, the question of knowing if some else has more than the others would have been without moral consequences
- It evades a levelling from the bottom, i.e. ameliorating someone's well-being, who is unflavoured, without ameliorating nobody's well-being. This is a flaw of classic egalitarianism. According to that, in a hypothetic society without ophthalmologists, those who are privileged, namely having two eyes, must be blinded so as to restore the injustice that certain people are born blind, i.e. under unfavourable conditions
- The definition of an absolute threshold leaves out questions of efficiency and arbitration, concerning the definition of a threshold in (leximin) egalitarianism. Characteristically, in a hypothetical situation of (leximin) egalitarianism, it is plausible that 100 litres from the swimming pool of a millionaire should be distributed to 100 poor families, so as to cover their basic needs, even if the bucket which will carry the amount of water is pierced and consequently only 10 litres will be finally delivered to the poor families.
- It escapes the burden of "*choice/ responsibility*". Defining an absolute threshold renders the question, if someone is responsible or not for his/ her unfavourable

situation, void of meaning. This is again the situation of someone who is blind as birth defect or a result of a dangerous activity. While (leximin) egalitarianism is preoccupied how this situation has been emerged and acts accordingly, this is not the case for "sufficientarism", which has for all a specific threshold of well-being.

Sufficientarism proposes a specification of the relevant threshold as a defined in terms of absolute, non-comparative conditions (Shiffrin 1999,; McMahan 1998; Meyer and Roser 2009; Huseby 2012). A unitary view of the threshold could be held according to which one and the same threshold would be applicable to all decisions. Even if one assumed that the same list of rights were attributable to all people (wherever and whenever they live), for example, those which are meant to protect basic capabilities of human beings, what these rights amount to will reflect contemporary social, economic, and cultural conditions (Sen 1984; Nussbaum 2000; Page 2006).

A sufficientarian conception of justice presupposes that equality as such does not matter (Frankfurt 1987) and it also has a built-in tendency to equality (Meyer, 2014). Moreover, the tendency is restricted in the following way:

"To benefit person X is more important than to benefit person Y, if X is below the threshold and if Y is better off than X. On a low level of well-being, equality is of derivative value. In other words, concerning the improvement of the position of the less well off, sufficientarianism holds both a negative and a positive thesis: Below the threshold the priority view is valid (this being the positive thesis), above the threshold the improvement of the position of the less well-off is of no particular concern (this being the negative thesis)" (Benbaji 2005; Brown 2005; Casal 2007).

We can distinguish between weak and strong interpretations of sufficientarianism (Crisp 2003; Benbaji 2006). According to weak sufficientarianism the priority to be given to people below the threshold decreases to zero at the threshold. However, the position of weak sufficientarianism can also make unreasonable demands on the currently living (unless all future people were to enjoy levels of well-being that are higher than those of all or most currently living people). For, even if we attribute particular weight to improving the well-being of people below the threshold, we might be able to do more good (in total) by benefiting many more people who are well off already—that is, if, as seems plausible, we give some weight to the well-being of people above the threshold (Meyer, 2014).

On the other hand, strong sufficientarianism has two specific characteristics (Meyer, 2014).

"First, to the group of persons whose improvement in well-being has absolute or lexical priority belong those whose level of well-being is below the threshold; to benefit persons below the threshold matters more the worse off they are. Second, and in addition, while within the group of both those below and those above the threshold, it matters more to benefit persons the more people are being benefited and the greater the benefit in question, trade-offs between persons above and below the threshold are precluded".

After this brief presentation, Gosseries (2011) articulates his position that "sustainability can be defined as "Brundtland's sufficientarianism". This means that "sustainability" entails the satisfaction of need i.e. basic needs, while further redistribution of welfare is avoided and not further demanded.

Based on that, Brundland's definition contains two "injustices" as it firstly focuses on the satisfaction of need and more narrowly seen, of basic needs. If those needs are satisfied for all the member of the current generation, then there is no need for a further redistribution of well- being to the current generation. Furthermore, there is a possibility of dissavings from the current generation, as long as the next generation is able to satisfy its own basic needs. This is a point of argument, as one should see the kind of dissavings the current generation is willing to make. This is more or less a question of the content of basic needs. A further injustice is that generational savings are authorized, as long as it does not compromise the capacity of all the members of the current generation to satisfy their own needs.

Surely, one could go on and continue a critique on "*Brundtland's sufficientarism*". Especially from an egalitarian point of view, the strengths of "*sufficientarianism*" can be transformed and articulated as possible defects of a sufficientary approach. The weaknesses of "sustainability" stem exactly from its definition. As it was explained in the previous chapter, the vagueness of the definition of sustainability has caused a series of problems, firstly on a pure policy basis. So, if one proceeds to the discipline of political philosophy, that vagueness is a source of a critique of the existing definition and what it brings with it.

Consequently, as it was analysed in the first chapter "sustainability" was employed by many institutions, governments, NGOs and other related stakeholders and was adapted according to their needs. This is also the case of sustainability in the "realm" of political philosophy. Additionally, as the concept of sustainability is something new to that discipline, it is open for an ample analysis of its traits. More specifically, scholars have attempted to incorporate traits of intergenerational justice into the concept of sustainability. The first one was presented above i.e. the sufficientarianism doctrine. The second interesting trait that is analysed and will be presented in detail in the next chapter is the concept of "basic needs".

The main aim of this chapter is to provide an analysis of sustainability viewed from the lens of intergenerational justice and not a critique of sustainability as a concept and more particularly a sufficientary concept. Sustainability is taken as constant. Its primary definition is not contested, but only adapted, fitting our basic purpose, i.e. to articulate and define sustainability in specific stages, as a part of intuitive process.

3.5 Sitting on the hill: How the view was

This chapter offered a concise analysis of sustainability viewed from the perspective of intergenerational justice. Its basic question was merely deontological, namely should we bequeath something to the next generation and if yes how?

For that reason the PhD thesis has focused on the discipline of political philosophy. From the abundance of theories concerning intergenerational justice, the theory of Rawls was selected as the one that could fit the basic traits of sustainability. Nevertheless, it was observed that the Rawls' theory could not be directly adopted, before some amendments are implemented. Hence, a “post structuralist” adaptation was attempted. In that way, the theory was amended in a way so its final product coincided with Gosseries thesis that sustainability can be seen a sufficientary concept, i.e. “Brundtland’s sufficientarism”. Again some flawed assumptions concerning the definition of sustainability have been observed. However, as it was mentioned above, this is the “raison d’ être” for this thesis and based on that, the research attempt aims to investigate further the interrelation between intergenerational justice and sustainability.

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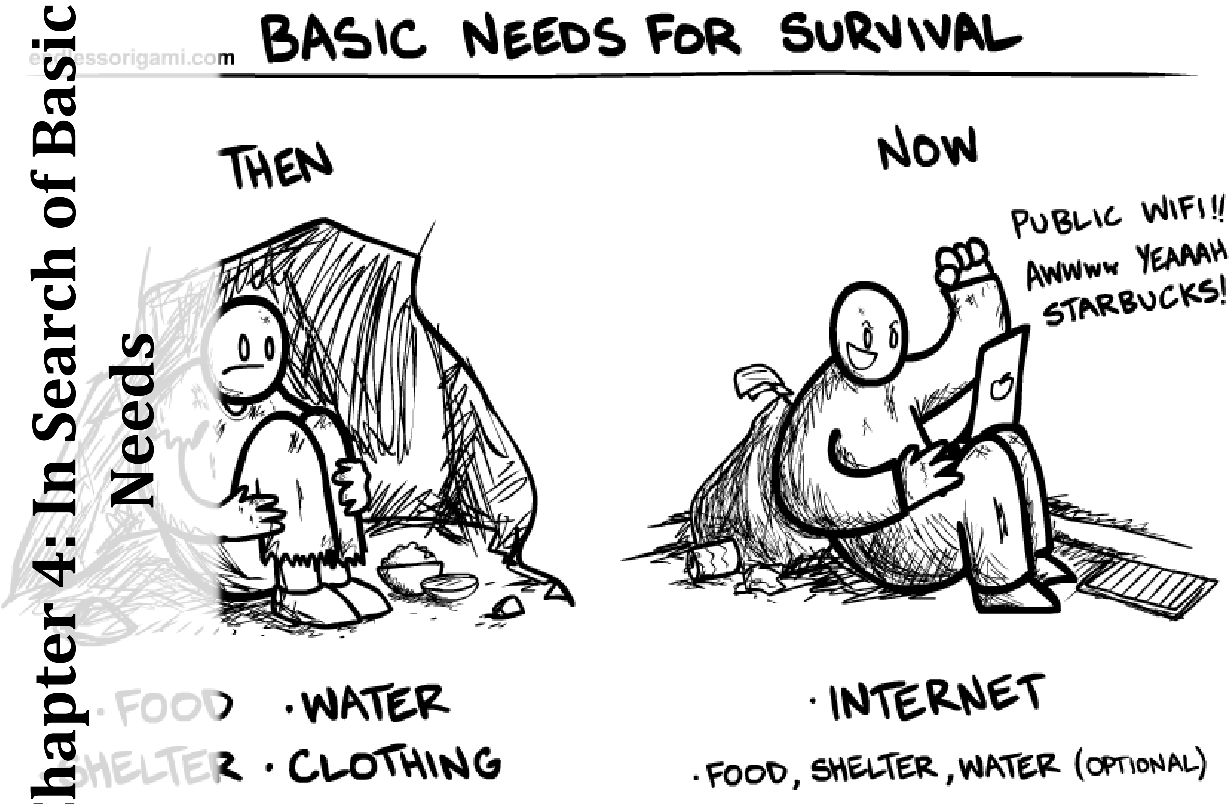
Chapter 4: In Search of Basic Needs



4 In Search of Basic Needs

After underlining the main points of Rawls' theory and providing a comprehensive approach of how sustainability can be integrated in the context of intergenerational justice, this chapter aims at analysing a number of specific traits of later developed theories of justice which focused on basic needs. Direct proponents can be considered Amartya Sen and Martha Nussbaum who have tried to elaborate their own approach, namely the Capability Approach, as far as justice is concerned.

This chapter presents an extensive overview of approaches that are primarily focused on intragenerational justice, i.e. justice between individuals and/or groups of one generation. Despite the fact that our analysis is based on intergenerational justice, Sen's and Nussbaum's approach provides one with the necessary feedback and input so as to proceed with the formation of a similar approach on the spectrum of intergenerational justice. The aim of this chapter is to answer the question: Are there specific needs that should be satisfied in order for an individual to attain a certain "threshold of well-being". A corollary question emerges: How is this "threshold" for this person defined?

The chapter begins with a thorough description of Amartya Sen's approach, known as the Capability Approach. Its main traits as well as its premises will be described. Similar to that approach, Martha Nussbaum's approach on basic needs is presented, as both scientists together have initiated the development of that approach. Nevertheless, Nussbaum has opted for a more determined analysis of basic needs. In addition, Max Neef's approach on basic needs is presented. In contrast with the other two, Max Neef is keen on presenting a very detailed and comprehensive list of basic needs that satisfy an individual's well-being. The chapter will conclude by presenting three new approaches that try to merge elements of all three aforesaid approaches while they try to integrate sustainability either explicitly or implicitly.

Chapter 4: In Search of Basic Needs

4.1 The Capability Approach: Amartya Sen's Approach

The Capability Approach (CA) can be considered as a theoretical framework that is based upon two normative claims that serve as the basic pillars on which this framework is developed (Robeyns, 2011). The first claim stresses the importance of freedom. Freedom is instrumental as it serves as an end for the attainment of an individual's well-being. The second claim is related with the content of freedom or how freedom is "translated" in the Capability Approach. Under that perspective, freedom connotes that freedom means the real opportunities "to do and to be what an individual has reason to value" (Robeyns, 2011).

Traces of the Capability Approach can be surely found in other philosophers such as Aristotle, Adam Smith and Karl Marx (see Nussbaum, 1988; Sen, 1993, 1999: 14, 24; Walsh, 2000). However, it was the economist philosopher Amartya Sen together with Martha Nussbaum who pioneered and developed this approach (Robeyns, 2011). It should be noted that the word "framework", "concept" and "approach" will be employed when referring to what Amartya Sen has developed. On the contrary, even Sen himself does not want to baptise ihis approach as a "theory", as this renders his analysis as rigid and very restrictive (Sen, 1992). In other words, the Capability Approach should be regarded as "a flexible and multi-purpose framework" that could be easily adapted to the respective needs of the research (Qizilbach, 2008).

Sen's willingness not to regard his approach as a theory is justified a posteriori as his flexible approach was employed and used in a number of disciplines such as political philosophy (Crocker, 2008), social sciences (Comin et al., 2008), gender studies (Robeyns, 2008) and welfare economics (Alkire, 2002; Wolff and de-Shalit, 2007). Despite its use in a very broad range of fields, the Capability Approach can be described as a conceptual framework that includes the following "normative exercises" (Robeyns, 2011)

- the assessment of individual well-being;
- the evaluation and assessment of social arrangements; and
- the design of policies and proposals about social change in society.

The Capability Approach in the above mentioned "exercises" highlights certain of peoples' beings and doings and their opportunities to realise those beings and doings. As it will be explained below, freedom is the utmost end that should be secured. Consequently, freedom is considered an end and not merely as a means.

Crocker and Robeyns (2009) suggest that the capability can be used in both a narrow and broader perspective. In the narrow perspective, the main research aim is to what information one should look at if it is to judge how well someone's life is going or has gone. This kind of information is needed in any account of well-being or human development and is perfectly suitable for interpersonal comparisons. In its broader sense, the Capability Approach not only evaluates the lives of individuals (as in the more narrow use), but also includes other considerations in its evaluations, thus enabling not only an interpersonal comparison but a more thorough analysis and criticism of the respective polity (government, society, institutions) as well as their policies.

> *"The Capability Approach is a normative theory, rather than an explanatory theory: in other words, it is not a theory that will explain poverty, inequality, or well-being, but rather a theory that helps us to conceptualize these notions. Nevertheless, the notions of functionings and capabilities in themselves can be employed as elements in explanations of social phenomena, or one can use these notions in descriptions of poverty, inequality, quality of life, and social change."*

Box 4-1: What is the Capability Approach? Source: Robeyns, 2011

4.1.1 The "nuts and bolts" of the Capability Approach

Sen's normative framework consists of two basic traits (Sen, 1999):

- **Functionings** are states of "being and doing" such as being well-nourished, having shelter. They should be distinguished from the commodities employed to achieve them (as "bicycling" is distinguishable from "possessing a bike").
- **Capability or capabilities** refer to the set of valuable functionings that a person has effective access to. Thus, a person's capability represents the effective freedom of an individual to choose between different functioning combinations – between different kinds of life – that she has reason to value.

As described above, what matters to Sen is what people are actually able to be and to do. The commodities, means, wealth people have at their disposal or their utility they acquire from those "*means*" (e.g. happiness) are not sufficient as they limit our holistic perspective. For that reason, Sen uses a very characteristic example, that of the bicycle. Having a bicycle (input- resource) does not suffice for the achieving a certain level of well-being, as this is contingent with other factors. The bicycle's value (and i.e. every input's) depends on each individual's ability to convert them into functioning, which is also dependent on their personal situation and physical status[2] (physiology), social norms and physical environment (Sen, 1999).

Resources, such as marketable goods and services, but also goods and services emerging from the non-market economy, including household production, have certain characteristics that make them of interest to people (Sen, 1992). For example, one may be interested in a bike not because it is an object made from certain materials with a specific shape and colour, but because it can take her to places where one wants to go, and in a faster way. These characteristics of a good or commodity enable or contribute to a functioning. A bike enables the functioning of mobility, to be able to move oneself freely and more rapidly than walking. The relation between a good and the achievement of certain beings and doings is captured with the term "*conversion factor*"': the degree in which a person can transform a resource into a functioning (Robeyns, 2011). For example, an able bodied person who was taught to ride a bicycle when he was a child has a high conversion factor enabling him to turn the bicycle into the ability to move around efficiently, whereas a person with a physical

[2] For example a person with amputated legs could not use a bicycle for her well-being, i.e. her functioning cannot be fulfilled

impairment or someone who was never taught to ride a bike has a very low conversion factor. The conversion factors thus represent how much functioning one can get out of a good or service; in our example, how much mobility the person can get out of a bicycle (Sen, 1999).

There are several different categories of “*conversion factors*” (Robeyns, 2005). All conversion factors influence how a person can be or is free to convert the characteristics of the resources into a functioning, yet the sources of these factors may differ. *Personal conversion factors* are internal to the person, such as metabolism, physical condition, sex, reading skills, or intelligence. If a person is disabled, is in bad physical condition, or has never learned to cycle, then the bike will be of limited help in enabling the functioning of mobility. *Social conversion factors* are factors from the society in which one lives, such as public policies, social norms, practices that unfairly discriminate, societal hierarchies, or power relations related to class, gender, race, or caste (Robeyns, 2011). In addition, *environmental conversion factors* emerge from the physical or built environment in which a person lives. These can be climate, pollution, the proneness to earthquakes, and the presence or absence of seas and oceans. Among aspects of the built environment are the stability of buildings, roads, and bridges, and the means of transportation and communication. For example: How much a bicycle contributes to a person's mobility depends on that person's physical condition (a personal conversion factor), the social mores including whether women are socially allowed to ride a bicycle (a social conversion factor), and the available of decent roads or bike paths (an environmental conversion factor).

The three types of conversion factors all stress that it is not sufficient to know the resources a person owns or can use in order to be able to assess the well-being that he or she has achieved or could achieve; rather, it is needed to know much more about the person and the circumstances in which he or she is living. Sen uses “capability” not to refer exclusively to a person's abilities or other internal powers but to refer to an opportunity made feasible, and constrained by, both internal (personal) and external (social and environmental) conversion factors (Crocker, 2008; Robeyns, 2005).

Figure 4-1 illustrates how the framework is working. On one side, are the resources or inputs one has. “Distilled” through the personal utilization function, the capabilities are formed. The personal utilization function includes the respective conversion factors (physical, social and environmental). “Capabilities” are seen as the real freedoms or opportunities to achieve functionings, i.e. beings and doings

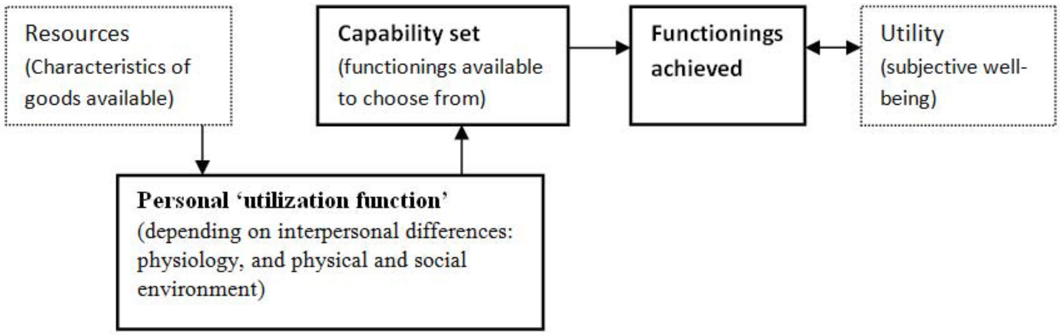


Figure 4-1: Outline of the core relationships of the Capability Approach. Source: Wells, 2011

After presenting the basic traits of the Capability Approach, the following dilemma is apparent: Which is the adequate metric so as to carry out an interpersonal comparison? Is it functionings, i.e. what one has achieved being or doing or capabilities i.e. what a person is/can be or do? Sen gives a straightforward answer to that question and considers capabilities the most adequate metric. Surely, functionings are constitutive of a person's being and these make the live of human beings lives (in contrast with soulless objects) and human (in contrast with animals or trees) (Robeyns, 2011). Nevertheless, looking into functionings exclusively, renders the capability framework almost identical to other approaches (subjective and resource based metrics). Therefore, capabilities entails not only what a person does or is but which opportunities are open to that person under the respective circumstances that include factors such as democracy, freedom and justice (Robeyns, 2011; Sen, 1999).

A very extreme example is the comparison between a handicapped person in a developed democratic society with extensive social welfare and of a person in a mountainous area of a developing country under a despotic regime. The first person apart from her physical condition that constrains her, lives in a society that facilitates her to target different functionings, i.e. her capability set is very broad. She can either work or at the same time receive social service payments, while she can also travel fairly easy as the public transport and the infrastructure is adapted to that group of people with special disabilities. On the contrary, a person living in secluded area has low prospects of traveling, of having a decent job, and while in the case of expressing a possible negative opinion about the regime in her country, she faces the danger of incarceration. Therefore, her capability set is deprived.

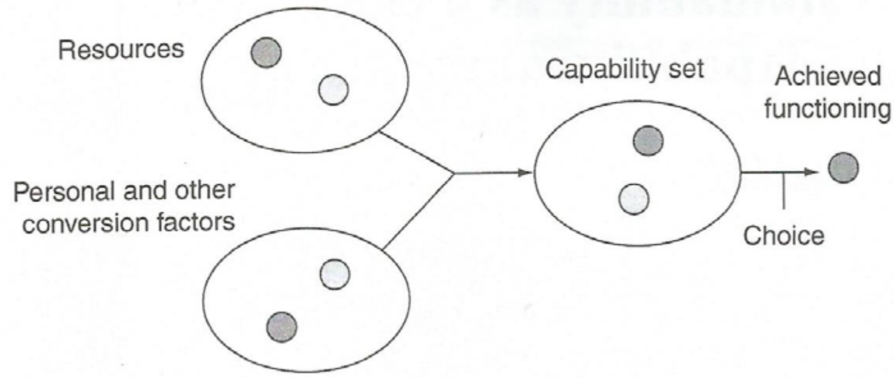
The dilemma between capabilities and functionings is pretty apparent in the scholars that worked with the Capability Approach. For that reason four basic considerations have been developed that privilege capabilities over functionings (Robeyns, 2011):

- By focusing on capabilities, one does not offer a biased and specific image and pattern of the traits a "good life" constitutes. On the contrary, looking at the broader perspective of capabilities one looks at the possible pathways and possibilities from which each person can choose (the normative argument)

- By focusing on capabilities, another factor is taken into consideration, that of personal responsibility, as each individual should be held responsible for her own choices
- By focusing on capabilities, light is shed on cases where a capability is available to an individual but only if other people want to recognize this ability. This parameter of who decides and should decide highlights the importance of agency and procedural fairness.

However, Sen has also proposed, to that tone, an interim category between capabilities and functionings, namely the concept of "*refined functionings*" that designate functionings that take note of available alternatives (Sen, 1992).

Another very important trait of how the Capability Approach is regarded is the so-called "means-ends" distinction". A prima facie, it can be argued that the Capability Approach focuses on the ends rather than the means as people differ in their ability to convert means into valuable opportunities or outcomes (Sen, 1992). The framework targets at evaluating policies and changes according to their impact on people's capabilities and their actual functionings. Nevertheless, the framework should be regarded in a perspective that focuses on people's ends in terms of beings and doings expressed in general terms: being literate, being mobile, and being able to hold a decent job. Whether a particular person then decides to translate these general capabilities into the more specific capabilities A, B or C (e.g., reading street signs, reading the newspaper, or reading the Bible), is dependent on them (Robeyns, 2011). This does not at all imply that means are not of primary importance. However, if one looks solely at means and their valuation then this retain a status of an instrumental valuation rather than an intrinsic valuation. In addition, by initiating from ends, we do not a priori assume that there is only one overridingly important means to that ends (such as income), but rather explicitly ask the question which types of means are important for the fostering and nurturing of a particular capability, or set of capabilities (Robeyns, 2005).



Symbol	●	○
Mode of moving about	Riding a bike	Going by bus
Resources	A bike	Money for the bus
Personal conversion factor	Ability of riding a bike	Ability of going by bus
Other conversion factors	Streets suitable for bikes	Availability of public transport

Figure 4-2: An illustration of capability and functionings. Source: Leßmann, 2011:44

Table 4-1 illustrates the above mentioned argument. If one looks only one factor i.e. the G.N.I of each country one could lose very important traits that form part of an individual's well-being. Consequently, looking exclusively at monetary terms does not always suffice. Therefore, Sen has also focused on examining what a person is capable of doing and of being. Logically, an individual in the Philippines might have low monetary resources, but have nevertheless a much greater life expectancy, even though, for example, minors have the opportunity of visiting school the same number of years in both countries. Therefore a more inclusive approach than that of presenting a number of hard (monetary) facts is needed.

Table 4-1: Perspicuous contrasts: The Philippines does more with less. Source: UNDP, 2015

	Philippines	South Africa
Gross National Income per capita (ppp)	$ 7,915	$12,122
Life expectancy (years)	68.4	57.2
Mean years of schooling	9	9.9

Of primary importance is that the definition of basic capabilities. Sen reserved the term "*basic capabilities*" to refer to a threshold level for the relevant capabilities. A basic capability is "*the ability to satisfy certain elementary and crucially important functionings up to certain levels*" (Sen 1992). Basic capabilities refer to the freedom to do some basic things considered necessary for survival and to avoid or escape poverty or other serious deprivations. The relevance of basic capabilities is "not so much in ranking living standards, but in deciding on a cut-off point for the purpose of assessing poverty and deprivation" (Sen 1987: 109).

Hence, while the notion of capabilities refers to a very broad range of opportunities, basic capabilities refer to the real opportunity to avoid poverty or to meet or exceed a threshold of well-being. Basic capabilities will thus be crucial for poverty analysis and in general for studying the well-being of the majority of people in poor countries, or for theories of justice that endorse sufficiency as their distributive rule. In affluent countries, by contrast, well-being analysis would often focus on capabilities that are less necessary for survival. It is important to acknowledge that the Capability Approach is not restricted to poverty and deprivation analysis but can also serve as a framework for, say, project or policy evaluations or inequality measurement in non-poor communities (Robeyns, 2011).

Sen is very cautious at defining this threshold level and consistently and explicitly refuses to defend “one pre-determined canonical list of capabilities, chosen by theorists without any general social discussion or public reasoning” (Sen, 2005).

Several capability scholars have tried in various ways to define a list of which capabilities should be of prime importance. Anderson (1999) argues that people should be entitled “to whatever capabilities are necessary to enable them to avoid or escape entanglement in oppressive social relationships” and “to the capabilities necessary for functioning as an equal citizen in a democratic state”. Alkire (2002) proposes to select capabilities based on John Finnis's practical reasoning approach. By iteratively asking “*Why do I do what I do?*” one comes to the most basic reasons for acting: life, knowledge, play, aesthetic experience, sociability (friendship), practical reasonableness, and religion. Robeyns (2003) has proposed some pragmatic criteria, mainly relevant for empirical research, for the selection of capabilities for the context of inequality and well-being assessments. Crocker (2008) explores the theory and practice of deliberative democracy to bring more specificity to democratic procedures and participatory institutions in the development of an agency-sensitive Capability Approach. Finally, Nussbaum will be even more ambitious and she provides categories of basic capabilities, while Max-Neef presents a perplexed matrix of basic capabilities.

One possible approach to the notion of “*basic capabilities*” is the weighting of these capabilities. However, this brings further dilemmas such as which relative weights should be attributed to each capability and how this can be measured and even aggregated. One possible system of weighting or aggregating is to use a democratic or some other social choice procedure (Chakraborty, 1996). The basic idea would be to encourage or prescribe that the relevant group of people decide on the weights. In some contexts, such as small-scale projects or evaluations, such capability weighting (and selection) could be done by participatory techniques. It has also been suggested that we may determine the weights of capabilities as a function of how much they contribute to overall life satisfaction or happiness (Schokkaert 2007). Yet this raises the question to what extent functionings are taken to be merely instrumental to another end, such as happiness, or indeed any other ultimate good.

4.2 The Human Development Approach: Nussbaum's approach

As it was briefly mentioned above, Martha Nussbaum follows the Capability Approach but she differentiates herself after a certain point. More specifically, she mainly criticises one of the core traits of the Capability Approach and opts for another strain of analysis. This core trait is the definition of basic capabilities.

Martha Nussbaum has collaborated with Amartya Sen on designing the Capabilities Approach. Obviously, Nussbaum has preserved the core definitions of the approach, namely the capabilities and functionings. Nevertheless, she aspires to transform them in a way that can serve her own research purposes. Her ultimate purpose is to put the approach to work in constructing a theory of basic social justice (Nussbaum, 2011:p.19). This aim is slightly different from that of Sen whose aim is to keep the approach as flexible as possible. Consequently, Nussbaum is more ambitious as far as her objectives are concerned. Of prime importance is her intention to construct a theory that will define a certain "threshold", i.e. a threshold of human dignity (Nussbaum, 2011:p.10).

Nussbaum has at first modified the basic definition of capabilities by creating two distinctive categories. The first one is called "*combined capabilities*" and is defined as the "*totality of the opportunities one has for choice and action in a specific political, social and economic situation*" (Nussbaum, 2011: p. 21). The second one is called "internal capabilities" and is related to "fluid states of a person" (personality traits, intellectual and emotional capacities, states of bodily fitness and health, internalized learning, skills of perception and movement) (Nussbaum, 2011). Nussbaum justifies her distinction as she argues that a society might facilitate the development of internal abilities (education, free speech, critical thinking) but it, however, hinders the exercise of those capabilities in that same society and vice versa (Nussbaum, 2011). There are specific examples that justify that "heuristic" distinction mainly in some Indian provinces or even in the Saddam-Hussein's-era Iraq, where literacy rates were very high but the secular state was extremely despotic, thus limiting the "internal capabilities".

In addition, Nussbaum proposes a third category of capabilities that will serve as the fundament of her prospective theory. This is the category of "*basic capabilities*", a sub-set of combined capabilities. According to Nussbaum the ultimate political goal for all human beings is that "*all should get above a certain threshold level of combined capability, in the sense not of coerced functioning but of substantial freedom to choose and act*" (Nussbaum, 2011:p.24).

By preserving the central meaning of functionings, without altering it, Nussbaum proceeds with her version of the capabilities approach, which defines clearly the basic capabilities. Her goal is to focus on the protection of areas of freedom so central that their removal makes a life not worthy of human dignity (Nussbaum, 2011: p.31). Finally, Nussbaum presents her list of her ten Central Capabilities, where a decent political order should secure to all citizens at least a threshold level of those (Nussbaum, 2011:p.33)

- Life

- Bodily Health
- Bodily Integrity
- Senses, Imagination and Thought
- Emotions
- Practical Reason
- Affiliation
- Other Species
- Play
- Control over one's environment

1. Life. Being able to live to the end of a human life of normal length; not dying prematurely, or before one's life is so reduced as to be not worth living.
2. Bodily Health. Being able to have good health, including reproductive health; to be adequately nourished; to have adequate shelter.
3. Bodily Integrity. Being able to move freely from place to place; to be secure against violent assault, including sexual assault and domestic violence; having opportunities for sexual satisfaction and for choice in matters of reproduction.
4. Senses, Imagination, and Thought. Being able to use the senses, to imagine, think, and reason and to do these things in a "truly human" way, a way informed and cultivated by an adequate education, including, but by no means limited to, literacy and basic mathematical and scientific training. Being able to use imagination and thought in connection with experiencing and producing works and events of one's own choice, religious, literary, musical, and so forth. Being able to use one's mind in ways protected by guarantees of freedom of expression with respect to both political and artistic speech, and freedom of religious exercise. Being able to have pleasurable experiences and to avoid non-beneficial pain.
5. Emotions. Being able to have attachments to things and people outside ourselves; to love those who love and care for us, to grieve at their absence; in general, to love, to grieve, to experience longing, gratitude, and justified anger. Not having one's emotional development blighted by fear and anxiety. (Supporting this capability means supporting forms of human association that can be shown to be crucial in their development.)
6. Practical Reason. Being able to form a conception of the good and to engage in critical reflection about the planning of one's life. (This entails protection for the liberty of conscience and religious observance.)
7. Affiliation. A. Being able to live with and toward others, to recognize and show concern for other human beings, to engage in various forms of social interaction; to be able to imagine the situation of another. (Protecting this capability means protecting institutions that constitute and nourish such forms of affiliation, and also protecting the freedom of assembly and political speech.).B.Having the social bases of self-respect and non-humiliation; being able to be treated as a dignified being whose worth is equal to that of others. This entails provisions of non-discrimination on the basis of race, sex, sexual orientation, ethnicity, caste, religion, national origin.
8. Other Species. Being able to live with concern for and in relation to animals, plants, and the world of nature.
9. Play. Being able to laugh, to play, to enjoy recreational activities.
10. Control over one's Environment. A. Political. Being able to participate effectively in political choices that govern one's life; having the right of political participation, protections of free speech and association. B. Material. Being able to hold property (both land and movable goods), and having property rights on an equal basis with others; having the right to seek employment on an equal basis with others; having the freedom from unwarranted search and seizure. In work, being able to work as a human being, exercising practical reason and entering into meaningful relationships of mutual recognition with other workers.

Box 4-2: Description of the Central Human Capabilities. Source: Nussbaum, 2011: pp.33-34

Apart from the introduction of the notion of "threshold", Nussbaum also highlights a very important element in her analysis, namely the natural environment. She acknowledges that the capabilities approach has undermined until recently the subject and the importance of natural environment and more specifically of environmental quality. Sen confines the discussion on environmental quality in matters related to population control, rearticulating his Malthussiannesque concerns over the growing population that will have consequences on the natural environment (Sen, 1992).

Nussbaum put the matter of environmental quality in very familiar context, that of intergenerational justice. She considers that environmental quality and ecosystems health is of primary importance not only for the current generation, but also and to a greater extent when future generations are to be taken into account (Nussbaum, 2011:p.164). Furthermore, she appraises the environmental economics approach that promotes the disaggregated consideration of a wide range of effects on different parts of human life.

It can be argued that Nussbaum aims to avoid the vagueness of Sen's version of the Capability Approach. She constructs the fundamentals of a comprehensive theory of justice by presenting a number of well-defined and concrete traits of the approach. For that reason, the matter of natural environment is put into the frame and is considered as a very important, yet undermined parameter.

4.3 Manfred Max Neef's Human Scale Development

In contrast to the capabilities approach doctrine, Manfred Max Neef proposes his own framework concerning the basic human needs. During his extensive experience as university professor in the US and in Latin America, he constructed a very defined and concrete approach, known as Human Scale Development and Human Needs.

According to Neef, human needs are regarded as ontological (stemming from the condition of being human), are few, finite and classifiable (as distinct from the conventional notion of conventional economic "wants" that are infinite and insatiable) (Neef et al., 1989:p.81). Therefore, he proceeds with a taxonomy/ classification of the human needs. According to him, this classification should be understandable, critical, and propositional and must combine scope with specificity (Neef et al., 1989:p.29):

His taxonomy consists of two basic parts. The first is the central matrix of needs and satisfiers, which presents the fundamental human needs from one viewpoint and from another view it defines those needs according to 4 different existential categories. Table 4-2 presents this matrix of needs and satisfiers.

Table 4-2: Matrix of Needs. Source: Neef et al., 1989: pp.33-34

Need	Being (qualities)	Having (things)	Doing (actions)	Interacting (settings)
Subsistence	physical and mental health	food, shelter, work	feed, clothe, rest, work	living environment, social setting
Protection	care, adaptability, autonomy	social security, health systems, work	co-operate, plan, take care of, help	social environment, dwelling
Affection	respect, sense of humour, generosity, sensuality	friendships, family, relationships with nature	share, take care of, sexual activity, express emotions	privacy, intimate spaces of togetherness
Understanding	critical capacity, curiosity, intuition	literature, teachers, policies, educational	analyse, study, meditate, investigate,	schools, families, universities, communities,
Participation	receptiveness, dedication, sense of humour	responsibilities, duties, work, rights	cooperate, dissent, express opinions	associations, parties, churches, neighbourhoods
Leisure	imagination, tranquillity, spontaneity	games, parties, peace of mind	day-dream, remember, relax, have fun	landscapes, intimate spaces, places to be alone
Creation	imagination, boldness, inventiveness, curiosity	abilities, skills, work, techniques	invent, build, design, work, compose, interpret	spaces for expression, workshops, audiences
Identity	sense of belonging, self-esteem, consistency	language, religions, work, customs, values, norms	get to know oneself, grow, commit oneself	places one belongs to, everyday settings
Freedom	autonomy, passion, self-esteem, open-mindedness	equal rights	dissent, choose, run risks, develop awareness	anywhere

"*Being*" registers personal or collective attributes that are expressed as nouns. "*Having*" includes institutions, norms, mechanisms, tools, laws, etc. that can be expressed in one or more words. "*Doing*" includes actions, personal or collective, that can be expressed as verbs. "*Interacting*" has locations and milieus .According to Neff et al. (1989), this "*stands for the Spanish verb estar or the German befinden, in sense of time and space, since there is no corresponding word in English, interacting was chosen á faut de mieux*".

Furthermore, Neef continues with the definition of his so-called satisfiers (how needs are met). For that reason, he provides a classification of those satisfiers (Neef, 1989:p.34):

- *Violators: claim to be satisfying needs, yet in fact make it more difficult to satisfy a need. E.g. drinking a soda advertised to quench your thirst, but the ingredients (such as caffeine or sodium salts) cause you health side effects.*
- *Pseudo Satisfiers: claim to be satisfying a need, yet in fact have little to no effect on really meeting such a need. For example, status symbols may help identify one's self initially, but there is always the potential to get absorbed in them and forget who you are without them.*
- *Inhibiting Satisfiers: those which over-satisfy a given need, which in turn seriously inhibits the possibility of satisfaction of other needs. Mostly originating in deep-rooted customs, habits and rituals. For example, an overprotective family stifles identity, freedom, understanding, and affection.*
- *Singular Satisfiers: satisfy one particular need only. These are neutral in regard to the satisfaction of other needs. They are usually institutionalised by voluntary, private sector, or government programs. For example, food/housing volunteer programs aid in satisfying subsistence for less fortunate people.*
- *Synergistic Satisfiers: satisfy a given need, while simultaneously contributing to the satisfaction of other needs. These are anti-authoritarian and represent a reversal of predominant values of competition and greed. For example, breast feeding gives child subsistence, and aids in the development in protection, affection, and identity.*

Neef's basic argument on constructing the matrix of fundamental human needs is that needs must be understood as "a system, the dynamics of which do not obey hierarchical linearities" (Neef et. al., 1989: p.50). In other words, no need is more important per se than any other, consequently there is no internal hierarchy between the needs; and there is no fixed order of precedence in the actualization of needs (that need B, for instance, can only be met after need A has been satisfied). Simultaneities, complementarities and trade-offs are characteristic of the system's behaviour. There are, however, limits to this generalisation. Neef, therefore, proposes the introduction of a pre-systemic threshold, below which "*a feeling of deprivation may be so severe that the urge to satisfy the given need may paralyze and overshadow any other Impulse or alternative*" (Neef et. al., 1989:p.51).

Neef is keen on implementing his approach on developed as well as developing countries and for that reason he presents a number of practical examples that include countries as well as regions (s. Table 4-3 and Table 4-4)

Table 4-3 : Negative Synthesis Matrix of Bolivia. Source: Neef et al., 1989:50

Need	Being (qualities)	Having (things)	Doing (actions)	Interacting (settings)
Subsistence	Ignorance	Corruption	Exploit	Lack of infrastructure, poor demographic distribution
Protection	Insecurity	Institutional arbitrariness	Discriminate	Spatial discrimination
Affection	Insecurity	Loss of moral values	Deceive and cheat	Geographic isolation , split families
Understanding	Ignorance	Obsolete educational system	Marginate, dogmatize	Inadequate milieus, lack of communication systems
Participation	Discrimination	Centralization, no respect for human rights	Prejudice	Lack of infrastructure
Leisure	Deorientation, repression	Lack of adequate educational systems	Manipulate	Lack of time for oneself due to survival efforts
Creation	Alienation	Education based on memorizing	Underestimate	Lack of adequate milieus
Identity	Domination	Lack of integration policies	Indoctrinate	Irrational urban growth
Freedom	Authoritarianism	Injustice	Dominate	Dependence

Table 4-4: Negative Synthesis Matrix of Sweden. Source: Neef et al., 1989:52

Need	Being (qualities)	Having (things)	Doing (actions)	Interacting (settings)
Subsistence	Meaninglessness, gluttony	Big scale society	Self-destroy	Environment exploitation
Protection	Fear, anonymity	Centralisation	Avoid responsibility, avoid contact	Pollution
Affection	Fear of closeness	Mass society	Avoid contact	Dehumanized architecture
Understanding	Prejudice	Fragmentation	Stress	Isolation
Participation	Powerlessness	Vast scaleness, expert rule	Subordinate	Isolation
Leisure	Lack of self-confidence	Protestant work ethic	Worry, fill up time with "important" things	Lack of time
Creation	"Who-are-you-to-tell-me" attitude	Mass conformity	Overestimate technocratic thinking	Lack of traditional expressions, vast distances between home and place
Identity	Lack of confidence, falseness	Official lies	Decide against convictions	Decisions made far from people affected
Freedom	Security orientation	Bureaucracy	Obey, overregulate	Conformity with city and housing planning

It should be noted that the abovementioned examples are dated from 1989 and reflect the specific image of the society of Bolivia and that of Sweden. It constitutes a “snapshot” of the particular era. This image might understandably have been transformed during later years.

Neef’s approach was not neglected but rather further developed and adapted accordingly (Cruz, 2006; Cuthill, 2003). These proposals, namely extensions consist of the elaboration of a “*Situational Matrix*” (Table 4-5) along with a “*Propositional matrix*” (Table 4-6). The first matrix interrelates human needs and satisfiers in a given state of affairs and situation and shows the combination of circumstances at a given moment (Cruz, 2006). The second matrix elaborates on the first one and describes potential satisfiers for change and existing programs favouring positive actions (Cruz, 2006:p.140).

Table 4-5: Elaboration of Situational Matrix. Source: Cruz, 2006:165-166

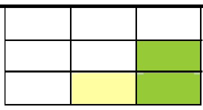
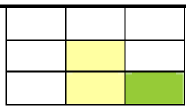
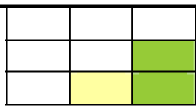
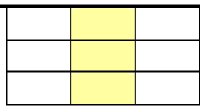
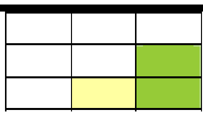
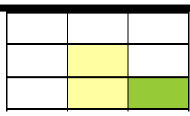
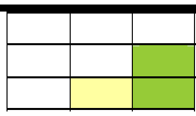
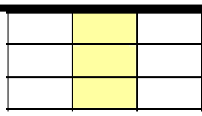
Needs according to existential characteristics **Needs** according to axiological characteristics	**BEING** (Personal/collective attributes)	**HAVING** (Institutions, norms, mechanism, tools)	**DOING** (Personal/collective actions)	**INTERACTING** (Spaces and environments)
SUBSISTENCE Fulfilment: **36.25%**	Life expectancy at risk – delicate physical health (sickle-cell anaemia, affecting afro-descendants) %15 (←- -)	Lack of sanitary services as well as food and shelter %15 (+→)	Scarce land production therefore food shortage and inability to work %50 (+→)	Inability to enjoy good vital surrounding and a place to live healthy %65 (+→)
PROTECTION Fulfilment : **26.25 %**	People is not safe from displacement , cannot define livelihoods autonomously (i.e. Alcantara people displaced: not able to fish & harvest - relocation at infertile lands) %15 (+→)	No institution to watch human security for Quilombos (food, work, housing, health and education threatened) %25 (+→)	Family cohesion is strong, but still they search coherence with their cultural values to protect their identity. %65 (+→)	No safe vital surroundings in resettlements (i.e. Alcantara: teenage pregnancy, drug use and prostitution) %0 (+→)
AFFECTION Fulfilment : **42.5%**	People lack of dignity , self-esteem, sense of belonging %25 (++→)	Land & territory are crucial part their cultural sense of belonging, family and friendship are being fragmentised %65 (+→)	Community values coerced – collective discontent %65 (+→)	**No sense of having a home** %15 (+→)
UNDERSTANDING Fulfilment : **26.25%**	Racial prejudgments and general ignorance about Quilombos culture %50 (+→)	Children starting school at 10 years of age %25 (←- -)	Population ignorance about rights and obligations, feeling overwhelmed from complicated judicial procedures %15 (←-)	Distancing from nature at multiple levels (livelihoods, education, religious) Families not being cultural backgrounds and knowledge references anymore %15 (←-)

PARTICIPATION Fulfilment : **25%**	Low cultural recognition inhibits participation therefore cannot potentiate responsibility, commitment, receptivity, etc.. %25 (**++**→)	No land recognition or ownership reduces participatory mechanism %25 (**+**→)	Community participatory activities seemed constrained due to lack of land ownership –this is also the motivation to start collective actions to achieve land concessions %65 (**+**→)	Isolation and inability to interact collectively for common goals %50 (←**-**)
LEISURE Fulfilment : **25%**	People have no lack of worry. No time for leisure fighting for subsistence. Uneasiness,disorientation, and feel discriminated %25 (←**-**)	No sensitivity to local holidays or important dates for Quilombola community %25 (←**- -**)	Not being able to celebrate/play/act in their own way %25 (**+**→)	Low possibility to enjoy one's surroundings, inability to be happy with one's own environment. %25 (**+**→)
CREATION Fulfilment : **36.25%**	Quilombolas are traditional communities with great imagination and intuition %50 (**+**→)	Collective division of work and exchange-product system is constrained %15 (←**-**)	Difficulties without land ownership to adopt different schemes for livelihoods or remaining with old ones %15 (**+**→)	Limited space for grouping, to express one-self. No spare time to create, investigate, etc.. % 65 (**+**→)
IDENTITY Fulfilment : **42.5%**	Strong collective feeling And spirit , nature-friendly and religiously oriented which cannot flourish without a physical space %65 (**+**→)	**Lack of recognition – (Customs, traditions, social, cultural and economic conditions which make them differ form other groups)** %65 (**+**→)	Committing and self-defining is difficult to attain with the lack of land possession %25 (**++**→)	Areas of belonging are not being recognized, therefore collective identity and common surroundings are in serious threat %15 (**+**→)
FREEDOM Fulfilment : **16.25%**	Autonomy and self-determination are constrained %0 (**++**→)	Equity of rights constrained / severe deprivation %15 (**+**→)	No option for disagreeing, devalued-diminished sense of freedom %25 (**+**→)	Quilombola communities are unable to BE and DO what they value in their own environment %25 (**++**→)

Table 4-6: Elaboration of Propositional Matrix. Source: Cruz, 2009:169-172

Needs according to existential characteristics **Needs** according to axiological characteristics	**BEING** (Personal/collective attributes)	**HAVING** (Institutions, norms, mechanism, tools)	**DOING** (Personal/collective actions)	**INTERACTING** (Spaces and environments)
SUBSISTENCE	**S**-physical health / Enough material goods to live a long a healthy life. Being healthy and enthusiastic people	**S**- implementation of National Policy of Black Population Health for example (already started)	**S**- advocating and campaigning for implementation of health programmes and land tenure acknowledge (already started)	**S**- Improve sanitary, and living infrastructure for Quilombos (The National health plan is still somehow discriminatory: More focus needed in Black peoples particularities)
Fulfilment :**70%**	%75	%65	%75	%65
	Exogenous / Singular & Sinergetic	Exogenous / Singular	Endogenous / Synergetic	Endogenous / Singular
	Singular satisfiers – respond to those aspects tackling particularly health issues, whereas **Synergetic** ones, are those contributing to overall well-being and self-reliance of the person.			
PROTECTION	**S**- autonomous self-defining	**S**- develop housing, education and health legislation favouring Quilombos (promote as well customary law mechanisms)	**S**- Advocating and campaigning (should be in the right direction)	**S**- special social re-adaptation programmes for the youngest (difficult target group)
Fulfilment : **70%**	%75	%65	%75	%65
	Endogenous / Synergetic	Exogenous & Endogenous / Synergetic	Endogenous / Pseudo-satisfier	Endogenous / Singular
	Synergetic satisfiers contribute to overall well-being and self-reliance of the person as they satisfy simultaneously other needs (e.g. affection, freedom, participation) **Pseudo-satisfier,** because if campaigning last too long real actions for change will never come.			
AFFECTION	**S**-Solidarity and respect for their values and collective identity	**S**- Land entitlement (Is in actual process but should continue until all Quiolombola communities have complete ownership of their lands)	**S**- Campanha Nacional Pe la Regularizaçao dos territórios de Quilombolos (Campaigns of the kind will watch for their community values)	**S**- Land entitlement (Land ownership will enhance converging spaces and a proper home)
Fulfilment : **75%**	%75	%75	%75	%75
	Exogenous & Endogenous /	Exogenous / Singular & Synergetic	Exogenous / Singular	Exogenous / Synergetic
	Synergetic satisfiers, contribute to overall well-being and self-reliance of the person as they satisfy simultaneously other needs (e.g. identity, protection, freedom)			

UNDERSTANDING	**S**-Collective conscience (having the right to preserve their culture, according to Brazilian Constitution)	**S**-Educational programmes more culturally orientated (i.e. formal implementation of law 10.639 –taught of Afro-Brazilian history) (Will take some time for real application)	**S**- Promoting capacity building on judicial tools to guarantee rights on land property and housing (Local Institutions like (CONAQ) are already doing workshops of the kind)	**S**- Communication without discrimination (family, school, and community oriented) (Educational and media strategies responding to affirmative action claims, www educational projects favouring racial-inclusive pedagogic practices)
Fulfilment : **72.5%**	%75	%65	%75	%75
	Exogenous / Synergetic	Exogenous / Singular	Endogenous / Synergetic	Exogenous / Synergetic
	Synergetic, satisfiers contribute to overall well-being and self-reliance of the person as they satisfy simultaneously other needs (e.g. identity, protection, subsistence, creation, leisure, freedom)			
PARTICIPATION	**S**- Dialogue, solidarity, respect (Should take place in both ways)	**S**- Quilombos participation actively in public life and political decisions (When land entitlement has been achieved, participation will be enforced. This also means that participation is also the motivation to achieve this goal)	**S**- Campanha Nacional Pe la Regularizaçao dos territórios de Quilombolos Promoting importance of participation in public life is already taking place in communities	**S**- Workshops for capacity building in Human rights. Associations like CONAQ & COHRE (e.g), are concentrating in articulating initiatives on participation
Fulfilment :**57.5** %	%65	%25	%75	%65
	Endogenous & Exogenous / Synergetic	Endogenous / Synergetic	Endogenous / Singular	Endogenous / Synergetic
	Synergetic satisfiers, contribute to overall well-being and self-reliance of the person as they satisfy simultaneously other needs (e.g. affection, identity, understanding, freedom)			

LEISURE				
	S-Solidarity and respect for their values and collective identity / Imagination & tranquillity	**S**-Observance of local holidays and important days for Quilombos (Might take place if entitlement is achieved and autonomy is acknowledge, however it is conditioned to local governmental approval)	**S**-New ways of having fun and celebrate (Might take place if entitlement is achieved and autonomy is acknowledge)	**S**- Land tenure and ownership to feel free to enjoy time for leisure activities (Might take place if entitlement is achieved, although space for leisure should be more specified and valued)
Fulfilment :**66.25** %	%75	%65	%75	%50
	Endogenous & Exogenous / Synergetic	Exogenous / Pseudo-satisfier	Endogenous / Synergetic	Endogenous & Exogenous / Synergetic
	Synergetic satisfiers, contribute to overall well-being and self-reliance of the person as they satisfy simultaneously other needs (e.g. identity, understanding, affection, freedom) **Pseudo-satisfier**, because if the action only concerns the observance of local holidays with no real intention of cultural recognition, the satisfier will risk to reduce its effectiveness in the long term.			
CREATION				
	S- Creativity, autonomy	**S**-Land entitlement and ownership for once	**S**- Campaigns in favour of Quilombola community recognition and dialogues w/ other regions (Are already taking place)	**S**- Land tenure and ownership to feel free to use spare time for create (Might take place if entitlement is achieved, although space for creation should be more specified and valued)
Fulfilment :**63.75** %	%75	%65	%65	%50
	Endogenous / Synergetic	Exogenous / Synergetic & Singular	Endogenous / Synergetic	Endogenous & Exogenous/ Synergetic
	Synergetic satisfiers, contribute to overall well-being and self-reliance of the person as they satisfy simultaneously other needs (e.g. freedom, protection, participation, leisure)			

IDENTITY	**S**-Solidarity, Authenticity (Is something that distinguishes Quilomobola communities) %75	**S**- Mechanisms on Human Rights observance and respect for minority groups (i.e. FIPIR,CNPIR,SEPPIR, but should be aware of particularities of Quilombos) %75	**S**- Campaigns in favour of Quilombola community recognition and dialogues w/ other regions (Are already taking place) %75	**S**-Campaigns to conscience people and governments on the importance for natural spaces and its relation to Quilombo identity (Are already taking place but need to multiplicate) %65
Fulfilment **:72.5** %	Endogenous / Synergetic	Exogenous / Synergetic	Endogenous / Synergetic	Endogenous & Exogenous / Synergetic
	Synergetic satisfiers, contribute to overall well-being and self-reliance of the person as they satisfy simultaneously other needs (e.g. freedom, protection, participation, leisure, affection, creation)			
FREEDOM	**S**- Respect, recognition and Self-reliance %75	**S**-Justice through mechanisms on Human Rights observance and respect for minority groups (FIPIR,CNPIR,SEPPIR, National Policy for the Promotion of Racial Equity / Racial Equity Statute) %75	**S**- Campaigning and participating to reach ownership and recognition i.e. workshops for capacity building in Human rights) (Are already taking place) %75	**S**- Appropriate spaces and environments to feel free and be able to BE and DO what Quilombola people value (Programs like: "The colour of culture", "Singing history", "History & Afro-Brazilian culture project" should be driven towards the enhancement of spaces to fulfil this need/deprivation) %75
Fulfilment : **75%**	Exogenous & Endogenous / Synergetic	Exogenous / Synergetic	Endogenous / Synergetic	Exogenous & Endogenous / Synergetic
	Synergetic satisfiers, contribute to overall well-being and self-reliance of the person as they satisfy simultaneously other needs (e.g. protection, subsistence, participation, leisure, creation)			

Table 4-5 and Table 4-6 can be seen as purely theoretical structures that are adapted to the respective research needs. Therefore, only one category can be thoroughly researched, revealing how well a certain policy performs. Cruz (2011) also underlines that the content of the substances are formed ideally built under participatory processes within specific cultural and social contexts.

It can be argued that all three approaches can be categorised according to their stance towards a definition of basic needs. Sen avoids referring to a specific list, while Nussbaum presents a list of ten central capabilities and Neef goes even further by defining a very concrete framework on human needs. The vagueness and clarification are based on ontological and deontological axioms that can be adequately justified. Surely, no approach can be discredited as inadequate. Each one has its own advantages and disadvantages. Nevertheless, it should be noted that these three approaches are not the only ones on basic human needs. Many "intermediate" approaches have also been developed, which not only aim at merging mainly the first two approaches but also provide us with some very useful information concerning the issues of sustainability.

4.4 Synthesis and Analysis: How to combine the Capability Approach, Human Scale Development along with Sustainable Development

The leitmotiv of some approaches is the so-called threshold level. In contrast with Chapter 3 threshold is presented from another perspective. Firstly, the existence of a threshold level is disputed. In addition, the threshold level is contingent on what the researcher aims a measuring. Is it a threshold of a mere subsistence level or something more arbitrary? Consequently which factors should be taken into consideration?

A further concern is how sustainability is entering this whole mental equation. One could underline that sustainability is apparent in Sen's framework, in the environmental conversion factors. Nussbaum was more explicit and underlined the importance of the so-called "*environment quality*" in an intragenerational and intergenerational context. Finally, Neef with his very explicit framework puts sustainability into the entire equation.

By having these three approaches as the basic sources, one's research could reer in two different research directions. The first is the "synthesis" pathway that aims to combine elements from all three approaches so as to construct a theoretical approach where sustainability is integrated. The second one is the "analysis" pathway. According to its results, the most appropriate direction will be selected and further analysed. Firstly, Rauschmayer et al. (2011) aim at merging the Capability Approach and Neef's approach. Secondly, Ortrud Leßmann's (2011) approach takes into consideration the Capability Approach. Thirdly, Nussbaum's approach is chosen, as Breena Holland (2014) presents a very systematic account on basic capabilities and environmental policy and sustainability. Apart from that, Anderson (2009) offers an alternative account, which can be situated between Sen's and Nussbaum's approaches and one of its basic traits was used by Holland (2014) so as assist her analysis.

4.4.1 Synthesis: Bridging the gap and moving from one approach to the other

Rauschmayer et al. (2011) has provided a very interesting analysis that combines the capabilities approach along with Neef's approach. He initiates his analysis with the concept of "needs". Needs are understood as requisites for meeting a given end (Gasper, 1996) and based on that, human flourishing is taken in its fullest sense as the given end and needs are the means for achieving this end (Alkire, 2002b). The next step is to define the strategies of achieving this end. For that reason, Neef's is considered as the ideal candidate to provide the "instrumental means" to fulfil the needs. By combining needs and strategies one attributes values, assigning a specific degree of importance. In this context, sustainability can be seen as a value that confers high importance to specific strategies to meet the particular needs of protection and affection (Rauschmayer et al., 2011). The final step of analysis consists of defining the quality of life that refers to individuals and consists of the individual's capabilities as well as the individual's well-being referring to "*emotional states and reflections of meaning in life based on the subjective experience of one's fulfilment of needs*" (Rauschmayer et al., 2011: 10).

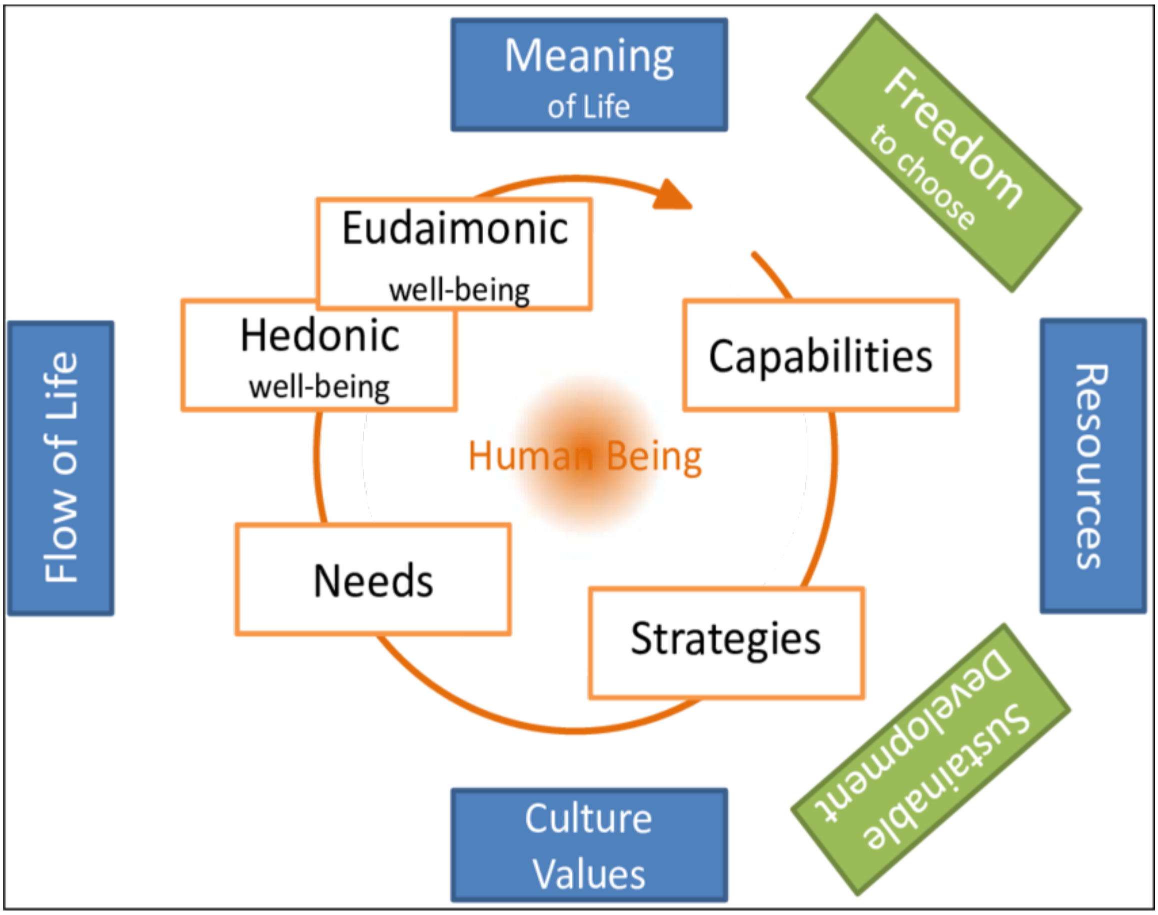


Figure 4-3: A process-based understanding of quality of life. Source: Rauschmayer et al., 2011:p.11

Figure 4-3 depicts the circular process in which elements of Sen's and Neef's concept are merged and where sustainable development is also integrated. More specifically, quality of life is the result of a circular generic process, linking all the aforementioned elements; capabilities requiring freedom (in Neef's sense) and resources, while the meeting of needs does not necessarily result in a high level of well-being (Rauschmayer et al., 2011).

Finally, sustainable development enters into the frame as a value related to the meaning of life and is contingent on the culture in which it is formulated. Sustainable development can be formulated into policies that refer to (Rauschmayer et al.,2011);

- The use and distribution of material resources,
- The wider availability of capabilities,
- The selection of strategies.

Based on that assumption, sustainable development which is inherent in a number of policies is only a subset of policies that aim at increasing people's capabilities. Therefore not all policies are directed to the attainment of sustainable development (Rauschmayer et al., 2011).

4.4.2 Analysis: "Taking sides" and Integrating Sustainability

4.4.2.1 Ortrud Leßmann's view

Ortrud Leßmann's theoretical analysis provides a very interesting analysis on how the Capability Approach can be merged with sustainable development. More specifically, Leßmann presents the challenges of merging those two concepts.

Firstly, Leßmann poses the dilemma of "*needs*" and "*capabilities*". On the one hand, needs are referred to sustainable development, while "*capabilities*" forms the basic trait of the Capability Approach. According to the scholar, the notion of capability supersedes needs in a number of ways. Firstly, "*capabilities*" offer a more thorough description and includes "*needs*" as means and as ends, while "*capabilities*" are more explicit at analysing how opportunity, i.e. freedom is employed so as to achieve a "full life" (Leßmann, 2011).

Secondly, the scholar considers the necessity of an approach that will combine the intragenerational character of the Capability Approach with the intergenerational substance of sustainability. Until now this combination has yet to be found (Leßmann, 2011)

Thirdly, there is the question of how to integrate environment and ecosystems in capabilities. Sustainable development uses the concept of ecosystem services that hint at the interaction of nature with human life (Daily, 1997) while, the Capabilities Approach focuses on the characteristics of goods and how these can contribute to well- being. While there is a certain correspondence between traits of the capabilities and elements of the ecosystem services, a potential correlation should be investigated (Leßmann, 2011).

Fourthly, sustainable development poses a double challenge for the Capability Approach. On the one hand, sustainable development takes the well-being of all people, present and future, into focus, whereas the Capability Approach concentrates on the individual. On the other hand, the concern for sustainability requires political strategies whereas the Capability Approach provides mainly a measure for evaluating well-being. However, "*agency takes a prominent position in Sen's framework if agency provides a path for reconciling the individualistic character of the CA with the global demands of sustainability and for underpinning political strategies towards sustainable development has yet to be explored in more depth*" (Leßmann, 2011).

Leßmann illustrates her attempt to merge these challenging concepts in Figure 4-4.

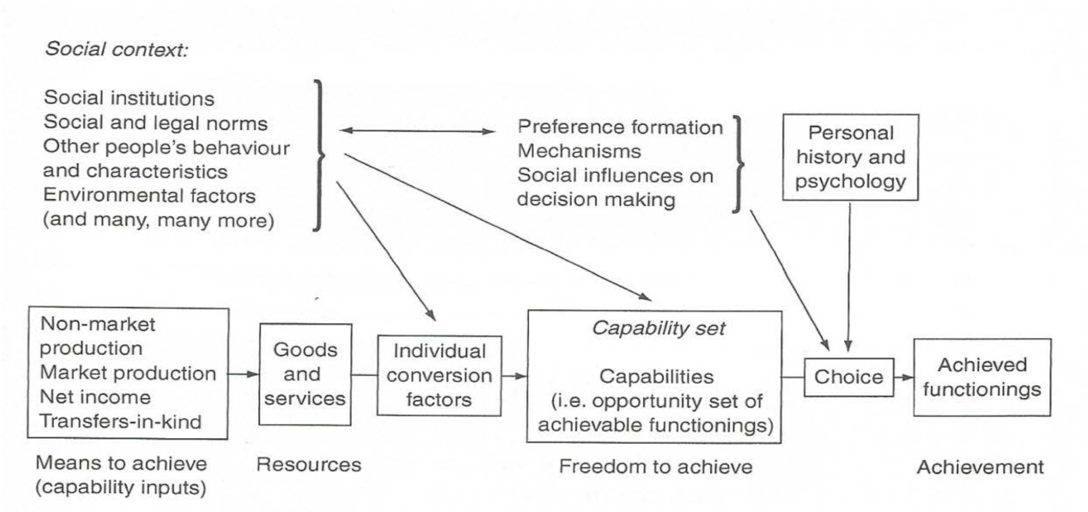


Figure 4-4: A stylized non-dynamic representation of a person's capability set and one's social and personal context.; Source: Leßmann, 2011:53, adapted by Robeyns 2005: 98.

The new element that enters the Leßmann's concept is the "*ecosystem service*", which would be further analysed in Ecosystem Services as the unit of analysis for sustainability. In Figure 4-4 the Capability Approach encompasses ecosystem services under the headings "*non-market production*" and "*environmental factors*" (Leßmann, 2011). It further hints at the complexity of effects by presenting a two-way arrow from the social context to preference formation. However, there is no straightforward way in which "*nonmarket production*" and "*environmental factors*" relate to the three functions of ecosystem services as provisioning, regulating and enriching. Ecosystem goods can be regarded as non-market products, but the role of biodiversity in enhancing capability has yet to be investigated. (However, the CA holds that other species should be preserved). The regulating services of the ecosystem may be regarded as environmental factors or environmental conditions that influence the conversion of goods and services into capability since they used or polluted air into fresh and breathable air. But they could as well be viewed as "nonmarket services", thus entering as resources for the production of capability as well. In this case they are what standard economic theory calls public goods: there is neither rivalry in consumption nor excludability from consumption.

These services have not been mentioned explicitly - and though the CA gives a more complex explanation of the role of goods and services in achieving well-being, it has as yet failed to notice the special characteristics of the regulating services of the ecosystem as much as the more traditional economic approaches. Furthermore, the regulating function of ecosystem services is realised in the course of time. Not only does the ecosystem needs time to deliver these services but the time it needs might be extended depending on the damaged the ecosystem has sustained. This is because Figure 4 4 is a "*non-dynamic representation*" and, thus, cannot display these processes in a timely fashion. There is no dynamic model of the ramifications of realising one combination of functionings today for the future or more specifically on one's future capability (Leßmann et all, 2009). Furthermore, through the cultural function of ecosystem services is missing the Capability

Approach it is taken this into careful consideration, as both Nussbaum (2000, 2006) and Sen (2004) refer to other species and their value for the human species.

However, the question remains how these concepts can be integrated. Here the notion of agency is employed, as Figure 4-5 illustrates.

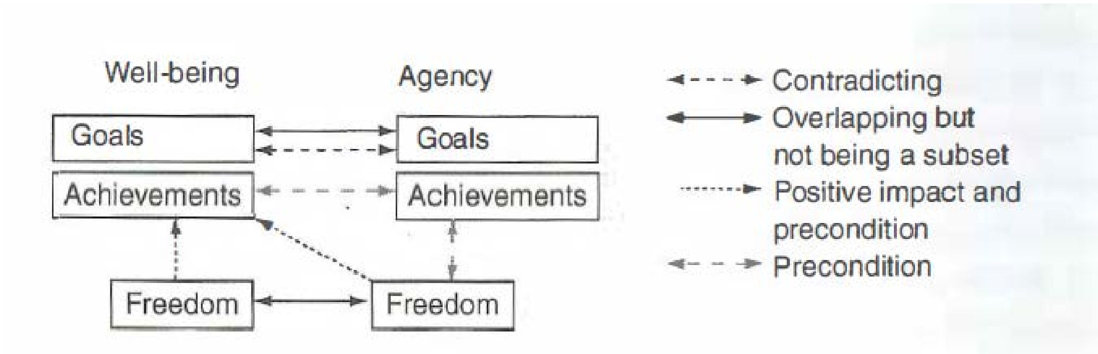


Figure 4-5: Interdependence of well-being and agency Source:Leßmann, 2011: 56.

According to the figure agency freedom is something broader than the defined well-being freedom, as there are goals that are pursued not out of self-interest, but out of sympathy or commitment to the well-being of the individual (Sen, 1985). Sustainable development is a goal that cannot entirely be based on sympathy since it is not restricted to sustaining the world for those we know and care about. There is an element of commitment involved. Anand and Sen (2000: 2034) refer to the obligation of sustainability· and the belief of sustainability as a commitment since obligations are one type of commitment and these obligations may impose constraints on the attainment of personal well-being. Nevertheless, an individual may pursue not only its own individual well-being but the goals of a variety of groups (families, friends, local communities, peer groups, and economic and social classes) (Sen 1977). Such goals can be translated into specific social rules of behaviour that take a universal character, difficult for the traditional economic analysis to grasp. Sustainability may be seen as one universal social rule, explained as “we may not know exactly who will live in the future, but long-run actions to protect the environment may still do a lot more good than disregarding the interests of unknown people in the future” (Sen 1991: 16).

Summarily, Leßmann’s approach seems a challenging and very promising concept that would be worthy of elaboration as she provides only the basic characteristic of this merge. Nevertheless, the theoretical foundation seems very robust, as it carefully adopts elements of both approaches and employs the notion of agency as the link between them.

4.4.2.2 Breena Holland’s Framework

Breena Holland’s framework sketches a theoretical and partly practical account of how the environment can be integrated to well-being and capabilities. In her book “*Allocating the Earth: A Distributional Framework for Protecting Capabilities in Environmental Law and Policy*”, Breena Holland presents an extensive account of how Martha Nussbaum’s “list of basic capabilities” can include environment and consequently sustainability.

Holland presents two basic paradigms, based on which environmental valuation is employed: The cost-benefit approach (CBA) and the Deliberative Monetary Valuation (DMV). In relation to CBA, her critique is destined towards its bias to economic efficiency rather than ecological protection, an argument that has been extensively used by critics of this method (Holland, 2014). In relation to DMV, though she firstly hails its innovative characteristics, such as the democratic participation of citizens (s. Spash, 2008) instead of isolated choices of individuals, she then continues to argue that the deliberative character of that process is actually a structural flaw, as individuals tend to express "*principle based valuations*" rather than individual preferences (Sagoff, 1998). Consequently, she firmly believes that a capabilities approach to environmental valuation is distinct from the existing approach, as the protection of environmental conditions is its primary priority. As Holland presents it (Holland, 2014):

"An approach to environmental valuation that prioritizes the protection of these ten capabilities will require assessing how they are impacted by changes in environmental quality. An account of a policy's distributional impact will therefore consist in an assessment of a policy's varying impact on the capabilities of the different people for whom it has consequences. In this context, the environment is treated as instrumental to the capabilities that make it possible for people to do and achieve different things".

In other words, environment is treated as a means through which the basic capabilities of Nussbaum are attained. Drawing on the work of Durraiappah (2004), the instrumental value of the environment can be defined as an "ecological meta- capability" that "underlies" all ten basic capabilities of Nussbaum. In other words, environment provides the necessary requirement so as the ten basic capabilities can be reached at a threshold level.

Holland provides three reasons why the ability to live one's life in the context of ecological conditions that ensure the protection of one's central human capabilities at a threshold level should be seen as a human capability with a special "meta" status. Firstly, while particular components of the natural environment are inseparable from human capabilities, the natural systems and processes that the ecological meta-capability would protect have a systemic relation to all the other capabilities that these material things lack. Any and all of the human capabilities are dependent on ecological conditions. Second, the ecological conditions, unlike political institutions and processes that enable human capabilities, are not something that humans can create. As failing to protect the environment is in many cases not necessarily correctable or compensable e.g. the destruction of the tropical forest so as to be turned into grazing farmland, the loss of ecological functioning has distinct importance to society. Moreover, while all the capabilities preserve an individual's option to choose not to exercise the relevant functioning, the choice of ecological non-functioning that the ecological meta-capability makes available has implications of a nature and scale that are unmatched by other capabilities (Holland, 2014). This is the case, when one decision will alter the ecological conditions and consequently have a grave impact on one's basic capabilities. This analysis will be more comprehensible once the concept of ecosystem services (s. Chapter 5) is thoroughly described.

After the question of "what should be valued" is answered, Holland proceeds to define "how the ecological meta-capability" should be valued. The first step is to identify the value. In contrast with the existing valuation methods, her aim is not to agree on the social value of environmental resource, as the DMV does; rather it is to specify the value of that resource in terms of particular capabilities that matter to people. Thus, the purpose of "dialogue" among the participants is not to transform preferences, but to specify abstract capabilities in a way that can reveal the environment's instrumental role in contributing to them (Holland, 2014). The second step is the value measurement, i.e. the quantification or otherwise comparison (but not purely commensurable) of the degree to which changes in environmental quality support or undermine the threshold level of people's central capabilities. In other words, it should be assessed how changes in environmental quality precipitated by environmental policies will impact the distinct capabilities of different people. The goal is to measure and compare the distributional impacts of a policy that changes environmental quality. For this purpose, the impact of a change in environmental quality on a particular capability of different people can be measured in the same way (s. Box 4.3). As in the example of John and Jane, the capabilities approach a unique trait, which other valuation methods suffer. As one looks into a specific capability and how this is achieved (the threshold level), the results are comparable between different persons, while possible spill-over effects are not taken into consideration (Holland, 2014). Therefore, aggregation is not necessary as in other valuation methods, looking only at the defined threshold level of each capability and comparing different results but always with the same denominator, the threshold of each capacity.

Despite the fact that the concept of "threshold" is familiar to experts of sustainability and ecological economics in general, it should be underlined that the "thresholds" employed by Holland point to the minimum level of each of every capabilities, defined my Nussbaum. Consequently, what is missing here, is the concept of "threshold" that concerns the environment, and more specifically, the attainment of "ecological meta-capability". For that reason, Holland (2014) employs a very interesting addition, the concept of "capability ceilings". Ceilings refer to "*maximum levels on the protection and provision of capabilities that can cause harm to others*" (Holland, 2014: p. 142). Establishing "ceilings" offer two extremely important traits. The first one is to limit the choice of each individual to pursue certain actions that "*are justifiable when those actions can contribute to the effect of undermining another person's minimum threshold of capability provision and protection*" (Holland, 2014:p. 142). In other words, ceilings confine the ways by which a capability can be transformed into a functioning. However, the second trait of establishing "capability ceilings" is of prime importance, which is that the central capabilities are ensured for each person at a minimum threshold level, by limiting a person's individual actions (Holland, 2008). Here, Holland implicates that through ceilings, potential capability conflicts can be resolved. Capability conflicts may arise from letting person's pursue individual actions that may prove to harm another person.

John and Jane: two asthma patients and the impact of air quality regulation on their health

Breena Holland (2014) presents a very fruitful example of how the capabilities can be measured and consequently how environment can enter as an 'ecological meta-capability".

[…]For instance, the impact of an increase in air quality on the capability for respiratory health for two different people, John and Jane, can be measured by the number of asthma attacks that will be triggered or avoided. If John has asthma but already lives in a relatively unpolluted area, then a relatively small increase in air quality may be effective in eliminating his asthma attacks. If Jane, on the other hand, also has asthma but lives in a relatively polluted area, then a small increase in air quality may not be effective in reducing the asthma attacks she suffers. Thus, while a policy improving air quality will increase John's capability for respiratory health, given Jane's circumstances it may do little to improve her respiratory health capability. Consequently, with respect to the respiratory health capability, we can say that John gets more benefits than Jane from the proposed change in air quality. If both John and Jane live in a society where the existing level of air quality already protects their respiratory health capability above the threshold level of what justice requires, then the policy change can claim to be just. However, if the respiratory health capability is not protected at a threshold level, then this is a policy that might push John above the level of health capability that justice requires, while failing to do the same for Jane […]

With this example it becomes apparent that the proposed value measurement provides values of the same capability that are comparable to each other. Nevertheless, this is only one aspect. A hypothetical increase of air quality might have further implications for other capabilities such recreation and/or play. However, […]"*In a capabilities approach to valuation these distinct capabilities need not be made commensurate with each other, so that John's overall level of capability improvement can be measured and then aggregated with the capability improvements that benefit others. Likewise, they need not be made commensurate so that different capabilities of different people can be compared in terms of aggregate capability improvements accruing to each person. Instead, a capabilities approach to environmental valuation need only compare how a change in environmental quality impacts the same capability (e.g. for respiratory health or enjoying a beautiful view) of different people (e.g. John and Jane), with respect to the threshold level of capability protection that justice requires. For this purpose, the method for measuring the value of changes in environmental quality must be the same with respect to particular capabilities, but not across capabilities".*

Box 4-3: The John and Jane story. Source: Holland, 2014.

Driving an SUV is a very characteristic example. Choosing to drive an SUV may satisfy the capability of "free move". Nevertheless, under the current technological development, SUV's heavy emissions may harm people with respiratory problems and their capability of playing. Theoretically, if one poses a limit, ceiling, as far as the capability of "free move" is concerned, translated literally into "a ban on SUVs", and may provide effective for attaining the capability of play of other individuals. Surely, the potential buyer of an SUV may feel restricted and consider this ban undemocratic, but free move can be realized by purchasing another low-emissions vehicle. Therefore, the threshold of "free move" is not violated, while at the same time the capability of play is assured at a threshold level (Holland, 2012). The concept of "capability ceilings" bears a great resemblance to the "harm principle" employed by John Stuart Mill (1959), which advocates peculiarly, as he was an ardent supporter of individual liberty, government action in case a person's actions harm others.

Additionally, Holland proposes how these "*capabilities ceilings*" can be defined. Apart from the reasons described above, ceilings are also crucial for the attainment of the "*ecological meta-capability*". Despite the fact that Holland aims to express her framework in terms of "well-being", the environment is not confined in a mere reference. For that reason, she proposes basically, that ceilings can be defined in relation to an ecological threshold (Holland, 2014). Therefore, "capability ceilings" refer to "ecological thresholds", namely the limits of individual action that if surpassed, may cause an irreparable harm to the environment. Such terms are similar to concepts like resilience analysed in the discipline of ecological economics.

Finally, Holland (2014) proceeds to implement her framework, coined as "*Capability Approach to regulatory rulemaking*" (CARR). Her main purpose is to prove that this decision making framework has an advantage against the CBA and DMV. Her main argument is that " *CARR […] gives precedence to the ideal of justice implicit in decisions that protect the environmental conditions necessary for ensuring each citizen has a threshold level of central human capabilities*" (Holland, 2014: p.170).

One the one hand, DMV offers some very interesting elements and engages public decision making processes. However, the prerequisites of DMV, such as democratic participation of all citizens to decision making (Crocker, 2008), might seem a prima facie ideal, although it is not implemented at all in practice. Ernst (2003) refers to a certain cases study (water quality standards in Chesapeake Bay), where voluntary reforms and participation led to the definition of lower standards. The main point of criticism here is related to the process of decision making. The inclusive and participatory model that is advocated by DMV can in practice create alliances and partnerships that can hinder the definition of environmental thresholds that really protect the environment (Holland, 2014). Such analysis gives rise to the problem of power. This is exercised and is directly related to the analysis Michel Foucault (2008) has provided for its concept of "biopolitics" (politics of life). Power might be proved decisive in defining who can participate in the decision making process and how can partnerships and a common belief system can be forged between the participants. Consequently, a DMV may finds itself in being a process that facilitates the introduction of not environmental friendly standards by certain stakeholders. Apart from that, individuals that are greatly harmed by this definition, such as people that live below the threshold of their basic capabilities, are not able to participate in the decision making process, as they lack the necessary resources to exercise power and thus influence decision making. CARR offers for that reason the remedy of legislation. Government, as representation of peoples' choices, and its regulatory authorities, based on their expertise and knowledge may provide these standards.

On the other hand, CBA advocates a solution, with which the flaws of DMV are remedied. For this reason CARR offers limited or selective empowerment of government and more specifically regulatory authorities so as to define environmental standards. Authorities should provide their expertise on the field and provide the necessary input, for the environmental standards to be defined with the help of the people. CARR also foresees provision, where experts are held accountable for their analysis, in order to avoid any bias (Holland, 2014). Once the “capabilities thresholds/ceilings” are defined, the decision making process can be based on those standards. Any action that surpasses the ceilings and inflicts damage on the thresholds is prohibited. There is no need in conducting a CBA analysis to prove that this action can be cost efficient and conforms to the Pareto criterion or even to the Kaldor-Hicks criterion, in other words that the aggregate benefits of the action prove to be in aggregate beneficial.

The ideal of social and environmental justice to which the CARR would hold administrative decisions about environmental policy accountable is already justified by the same sources of democratic legitimacy that authorize both democratic and economic approaches to regulatory rulemaking. However, CARR can incorporate a commitment to public participation in democratic rulemaking by involving citizens in the process of specifying the capabilities to which environmental protection is relevant. While experts will inevitably be necessary for identifying how changes in environmental protection are relevant to the capabilities citizens value, constraining experts’ power to make judgments that are insensitive to citizens’ interests by limiting their role to the provision of empirical expertise and by holding them accountable when they demonstrate a pattern of consistently underestimating the negative impact of environmental changes on citizens’ capabilities will also be necessary. In this way, the CARR treats citizens as active agents in determining the relevance of the environment to the ends they personally or collectively value while constraining the potential of specialized expertise to shape policy outcomes in ways that disregard citizens’ interests (Holland, 2014).

The CARR does hold regulatory rulemaking accountable to the political ideas that a capabilities approach to social and environmental justice embodies, and it should be understood as a way to secure conditions of democracy rather than as a threat to democratic deliberation. The success of genuinely democratic political processes requires citizens that are free from unhealthy environmental exposures and it requires decision-making contexts in which individuals and communities that have personally and culturally meaningful relationships to nature are fully recognized as political equals. If this is not respected, it can function to undermine one’s sense of political membership, rendering political participation either unworthy of one’s efforts or an unproductive use of one’s time (Holland, 2014).

As Holland (2014: p.196) puts it “*because a CARR requires protecting the environmental conditions that enable people’s capabilities—including the capability for political control* *over one's environment—it should be understood as also protecting the conditions of effective political participation and the kind of political agency this requires. Furthermore, because environmental conditions are largely created by ecological relationships that humans neither understand nor control, the forms of misrecognition that environmental degradation can create*".

4.5 Conclusion: Ensuring basic needs

This chapter, dedicated to intragenerational justice, began with a thorough description of Amartya Sen's approach, known as the Capability Approach. Its main traits as well it premises were described. Interestingly, Sen aims at constructing a flexible concept, that will be adapted to the research goals and for that reason he does aim to construct a theory. Similar to that approach but having other principles, Martha Nussbaum's approach on basic needs was presented, as both scientists have initiated the development of that approach together. Nevertheless, Nussbaum have opted for a more determined analysis of basic needs. In addition, Max Neef's approach on basic needs was presented. In contrast with the other two, Max Neef is keen on presenting a very detailed and comprehensive list of basic needs that satisfy an individual's well-being.

After presenting the three basic approaches, three other approaches, that attempted to combine intragenerational justice with sustainability, were presented.

Rauschmayer and Leßmann try to integrate sustainability explicitly. While Rauschmayer attempts to merge Max Neef's concept with the notion of sustainability, Leßmann's efforts focus on putting together the Capability Approach and sustainability. Agency plays the key role in his analysis that ensures the harmonic co-existence of two concepts with different characteristics. In any case, sustainability is view as a policy goal in specific policies that coincide with the fulfilment of human well-being. Ortrud Leßmann tries specifically to create a unit for analysing sustainability and subsequently well-being, ecosystem services. This trait will be adopted and developed further in Chapter 5, as ecosystems systems expect to fulfil the main research question, i.e. the attainment of sustainability. However, more elaboration is needed for both attempts.

Breena Holland tries to provide a more extensive account on how environment can be inserted in the well-being equation. Here sustainability is implied and is firstly defined as "*ecological meta-capability*". Furthermore, "capability thresholds and ceilings" are defined. Capability thresholds refer to the minimum level an individual's basic capabilities should be assured, while capability ceilings refer to the maximum levels of basic capabilities an individual is allowed to attain. If those ceilings are surpassed, this can lead to harming other individual's basic capabilities. Such ceilings are directly correlated and defined by ecological thresholds. This remark points implicitly to sustainability that shares the same characteristic. Surely, Holland does try to provide a more practical account of how basic capabilities can be assured, by ensuring a viable environment. Nevertheless, her attempt is focusing on individual well-being. As her framework is meticulously sketched, her effort can serve as a useful theoretical foundation, which can be expanded to include sustainability explicitly. Here the role of agency may provide the necessary link so as the CARR can be elaborated.

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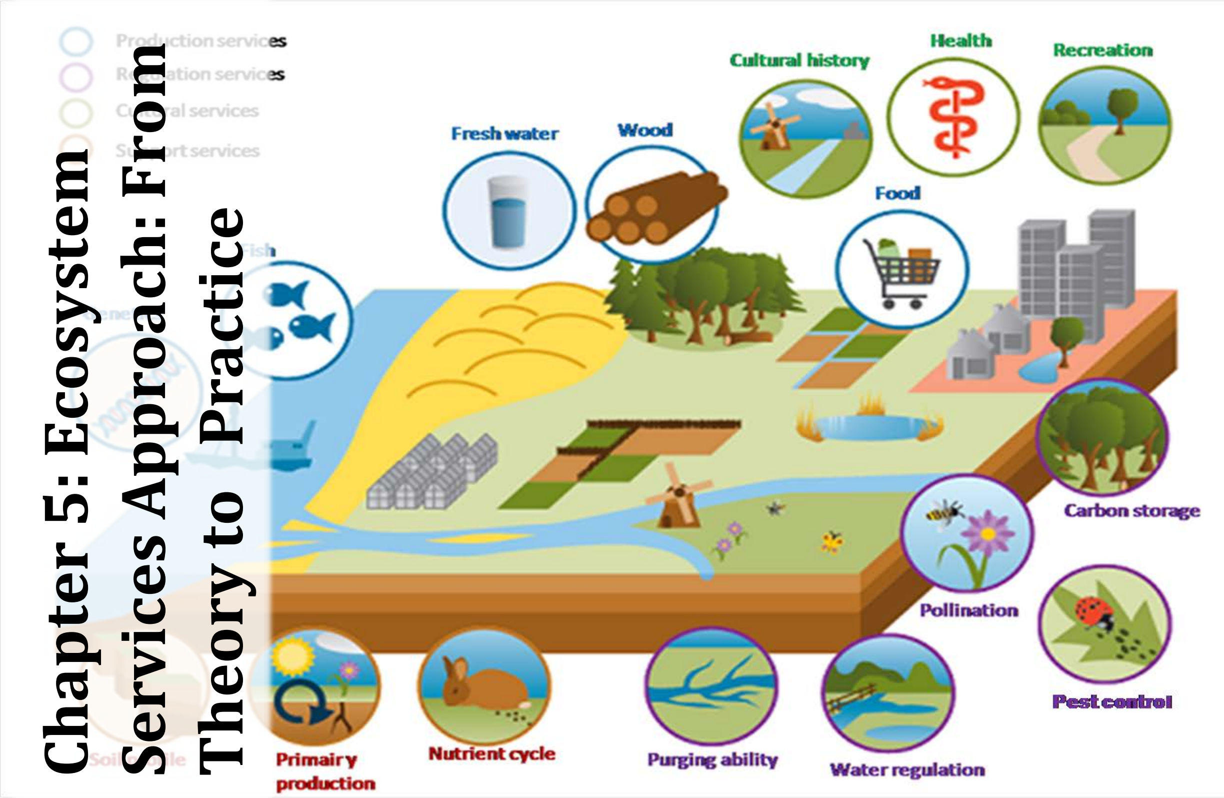
Chapter 5: Ecosystem Services Approach: From Theory to Practice



Chapter 5 : Ecosystem Services Approach: From Theory to Practice

5 Ecosystem Services as the unit of analysis for sustainability

The notion of sustainability and concept of "well-being" have been analysed. This chapter is dedicated to the Ecosystem Services Framework (ESF) as it can be seen as an instrument with which well-being can be attained. "Well-being" will be defined as "*the meta-capability*" that ensures the necessary conditions for the attainment of the basic capabilities. In addition, ESF aims at merging and integrating both sustainability and well-being. Primarily, it seems that the Ecosystem Services Assessment takes the notion of sustainability for granted and surely sustainability constitutes a foundation of the Ecosystem Services concept and is accepted as one of its priorities. However, it is interesting that the term is not restricted anymore to ecological stability. Sustainability enters the "realm" of well-being and is investigated as such. It is clear that there is a tendency to operationalise Brundlandt's notion of sustainability, which is merely the definition of sustainable development, and is expressed in Ecosystem Services Assessment as "sustained well-being".

Firstly, ESF will be presented. More specifically, its basic characteristics, purpose, categorization and development throughout the last fifteen years will be presented. The focus will be basically on how sustainability is expressed in the Framework and how well-being is assessed.

Secondly, the concept of justice, a specific trait of the ES Framework will be analysed. T. Expressed in "well-being" terms, one will look at how the application of ES ensures well-being and how these can ensure the satisfaction of the "meta-capability" expressed in the previous chapter.

Chapter 5 : Ecosystem Services Approach: From Theory to Practice

5.1 Ecosystem Services Framework: From a theoretical approach to policy implementation

Sustainability is profoundly integrated but it seems that as the Ecosystem Services Assessment matures, the notion of sustainability is taken for granted. It is clear that sustainability is a foundation of the Ecosystem Services (ES) concept and is accepted as one of its priorities. Apart from that, ES successfully merge sustainable development and well-being through the concept of "sustained well-being".

5.1.1 Ecosystem Services Framework. The frontrunners.

Currently, the concept of ecosystem services is one of the central themes in the scientific and environmental policy debates over the goal of preserving our natural resources. Therefore, a holistic view of our ambient spatial structures as a synthesis of natural and societal processes is indispensable in order to fully grasp the entire context of ecosystem services. The earliest signs for such a view can possibly be attributed to Alexander von Humboldt (1769–1859), who, by means of observation and measurement, sought to determine the '*Totalcharakter*' (total character) of the region of the earth, and observed in his later works that only research that keeps the balance between specialisation and integration in nature as a whole could guarantee the desirable conditions for human life (Mannsfeld and Grunewald, 2014).

Nevertheless, Humboldt's basic concept of the character of nature as a whole with reference to societal and natural-scientific aspects is still a challenging question (Neef, 1971). Ernst Haeckel (1866) approached the issue from the biological point of view and coined the term "ecology" to describe this *'interaction' between the animate and inanimate elements in nature*; later, with Troll's (1939) landscape ecology, the term would incorporate the inseparable links between the biological and the geological components of our environment, by encompassing anthropogenic effect factors, and thus describing and emphasizing the systemic context, which the theory of landscape ecology saw in the effective connection between nature, technology, and society (Neef 1967: 41). Neef describes this complex as follows:

"Hence, landscape ecology, although oriented toward the natural-scientific order of matter, must incorporate all factors which stem from the work of humankind and which will impact the natural balance."

In the following decades, analysis and interpretation of the so-called "*Totalcharakter*" began to gradually take into consideration the factor humankind, and, conversely, recognise the positive and negative effects of natural factors on human desires for utilisation(Mannsfeld and Grunewald, 2014).

The influence of late nineteenth-century economists (Adam Smith, Johann Heinrich von Thünen and Karl Marx in particular) through the theoretical conceptualisation human influence on nature succeeded in overcoming the deterministic view with regard to the human factor in the real environment. The economists pointed out a problem in the then-accepted views of the relationships between humankind and nature, and they should therefore be seen as contributors' to today's modern ES concepts. Specifically, labour processes were considered as the key factor in the interaction between humankind and nature, by which the necessary conditions for human existence were generated and upheld–entirely on the basis of natural and environmental conditions (Mannsfeld and Grunewald, 2014).

Marx used the term "*metabolism between society and nature*" to describe the category under which he subsumed the role of humankind in withdrawing those materials from the landscape needed for its economic activity, so as to fulfil the necessities of life. He expressed this as follows (Marx, 1867:7)

"Labour is, in the first place, a process in which both man [sic] and Nature participate, and in which man of his own accord starts, regulates, and controls the material re-actions between himself and Nature. He opposes himself to Nature as one of her own forces."

In this context, he also pointed to "*free services*" of nature, which positively affected the process of this metabolism. He underlined that, such services of nature as photosynthesis, pollination, etc. as a result of the effects of natural forces–i.e. with no labour effort–positively accompany this metabolism, and thus substitute for human activity.

Later, Alfred Hettner (1859–1941) raised the postulate of a "*practical geography*" (Hettner, 1927), the core statement of which was to evaluate and predict the effects of human impacts and changes on the basis of knowledge of the causal contexts of natural processes. From that he drew the conclusion that such an evaluation should primarily be derived from the given state of the natural systems in the cultural landscape, and that scientifically grounded proposals for improving utilization should embrace concepts to preserve and protect the forces of nature. This surely bears a great resemblance to the instrument of compensation/offsetting the impacts of human use of natural resources or the environmental impact assessment. The basic assumption that if Marx's metabolic process becomes critical, as is observed today, the effects caused by use processes must be ascertained systematically and according to a number of different standards. Otherwise, given the continued overtaxing of nature's "free services" the healthy development of ecosystems, i.e. a development subjected to only low levels of disturbance and detrimental interference, can no longer be guaranteed. In this respect, it is no coincidence that the ES concept and its numerous predecessors have placed the preservation of the precious forces of nature at the centre of their considerations (Grunewald and Bastian, 2015).

5.1.2 Ecosystem Services Framework: Forming the theoretical framework

Although elements of the Ecosystem Services concept can be traced back to the 19th century (Marsh, 1864), scientific dialogue on Ecosystem Services was initiated in the late 60's and 70's by a number of professors (Ehrlich, 1981; Heliwell, 1969; King, 1966; Odum and Odum). The main point of investigation was the role of functions of nature to human societies (Braat & DeGroot, 2012; s. Gómez- Baggethun, 2010 on the history of Ecosystem Services).

It should be noted that discussion on Ecosystem Services was not confined in some scientific communities of the English speaking world, as some scholars argue (Gómez- Baggethun, 2010). One should also look at how the German speaking scientific community has also provided necessary input for the formation of the theoretical framework of the Ecosystem Services. Especially, the German geographic community has slowly begun to approach the question of the extent to which it is necessary and possible to refer to the service capacity of a natural abundance (natural balance) which functions in a manner appropriate to the ecosystem (Grunewald and Bastian, 2015).

One early source is Bobek and Schmithüsen (1949). They designated "*regional nature*" (Landesnatur; a term meaning the totality of naturally provided interactive contexts) in the cultural landscape as a range of potentials, and consequently a spatial pattern of arrangements for naturally provided development possibilities (societal use intentions). Schultze (1957) defined the suitability of certain earth regions for use purposes even more concretely, and suggested that this determination of suitability be reformulated into a determination of the cultural-geographical potential of an area. The growing exploitation of natural resources, with the well-known consequences for the condition of 'protected goods", confronted society and specific scientific disciplines with the task of seeking answers and proposing solutions as to how to estimate the service capacity of natural systems and how to preserve and secure them over the long term (Grunewald and Bastian, 2015).

Additionally, Neef (1966) presented an initial study for the evaluation of the potentials of natural systems. This study involved the concept of making all aspects of natural factors comparable with the anthropogenic creations in the cultural landscape, and similarly capable of valuation, by defining their various elements in terms of energy content. He entitled this study in which he describes the use of this energy content concept for the elucidation of the relationships between naturally related and economic components of societal activity in the natural environment "*Questions of regional economic potentials*" (Grunewald and Bastian, 2015). Neef considered it as an important part of this concept and stressed the necessity to translate natural scientific findings into societally familiar, i.e. primarily economic categories if utility, sustainability, resilience and protection of natural resources were to be considered as societal activities at all. Neef saw his proposal, coined as "*the transformation problem*" as crucial towards objectifying the various processes of nature and society, and the transition from one causal area to another, and towards making the metabolism between human society and nature (Neef, 1969).

However, the proposed exclusive use of an energy scale (Neef, 1966) is methodologically difficult to implement, especially with regard to the specific-use demands of society upon the natural-spatial service capacity. The later proposals by von Haase (1973, 1978) provided a plausible solution to that barrier: Instead of energy as the standard of measurement for service capacity, a thorough analysis of the characteristics of the "Naturkapital" (natural capital) was to be employed in order to evaluate the fulfilment of basic societal functions.

Chapter 5 : Ecosystem Services Approach: From Theory to Practice

Once the scientific and social goals were clearly defined did material and energetic properties of the services of nature become “potentials”, and as they referred to the specific distribution of such service possibilities in the spatial context, “natural-spatial potentials”. Thus, the concept is able to illustrate not only the actual degree of tolerance towards societal utilization, but also the resilience, especially under the conditions of realistic multiple utilizations (Grunewald and Bastian, 2015). The spatially differentiated service capacity of nature suitable for societal development processes has been defined as the natural-spatial potential. Due to the different demands placed upon this capacity by society, it is, for methodological reasons, structured into a number of sub-potentials (partial natural spatial potentials), including for example:

- The Biotic Yield Potential or the capacity to produce organic substances and to regenerate the conditions for such production (site fertility).
- The Biotic Regulation Potential or the capacity to sustain biological processes and to regulate them once again after disturbances (the biodiversity aspect).
- The Recreation Potential or the capacity of nature to contribute to the recreation and health of people by psychological and physical effects.

These brief examples describing the properties of potentials indeed show that the opinion that the concept of natural spatial potential puts too much emphasis on its natural-scientific elements and fails to sufficiently capture societal or economic aspects is unfounded.

Returning to the basic history of ES, there has been a number of publications concerning the evaluation framework of functions of nature during the 70’s and 80’s (Gómez- Baggethun, 2009) but it was not until the mid-90’s where the Ecosystem Services have gained popularity and their “mainstreaming” phase (Gómez- Baggethun, 2010). This was marked by the publication of “*Nature’s Services: Societal Dependence on Natural Systems*” (Daily, 1997) with which Ecosystem Services entered the international environmental policy agenda.

The book, a collaboration of various researchers aimed at delineating the framework for Ecosystem Services; it paved the way for the development of the Ecosystem Services approach and contributed to its increasing popularity from that point onwards.

As the title of the book insinuates, this work sets the ambitious target of providing valuation for Ecosystem Services by identifying firstly nature’s services to human societies (Daily, 1997).

Ecosystem Services are defined as *“the conditions and processes through which natural ecosystems and the species that make them up, sustain and fulfil human life”* (Daily, 1997: 3). Firstly, a thorough examination on the philosophical foundations of valuation, thus advocating utilitarianism is presented, while Constanza and Folke (1998) continue in setting the 3 primary goals of valuation: efficiency, fairness and sustainability. It is argued that societies should manage to fulfil all three so as to succeed in a co-evolutionary adaption of the human and natural system (Norgard, 1994).

Chapter 5 : Ecosystem Services Approach: From Theory to Practice

Ecosystem Services valuation is confronted with a threefold challenge: efficiency, fairness and sustainability (Daily, 1997:.49). Decisions are based on the context in which one is situated and the goal one is aiming at. However, Ecosystem Services valuation embraces the fulfilment of all three targets. The logical next step after goal-setting is the formulation of the framework in which human and natural systems are interdependent, entwined and in which the main goal is accomplishing all three goals, which will be formed in a democratic environment (Daily, 1997: 54) as well as in a shared dialogue and discussion base (Daily, 1997: 58).

Ecosystem Services are categorized into 2 groups: the first is the so-called "*overaching*" services such as climate regulation and the second one is based on the biomes' taxonomy.

Constanza et al. (1998) continued with an article in Nature by presenting an ambitious global valuation of Ecosystem Services. Here Ecosystem Services are considered as "Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions" with Ecosystem Functions defined as "the habitat, biological or system properties or processes of ecosystems" (Constanza et al., 1998: 253). The goal of this paper is more blatant and clear because it provides an estimation of the total global value of Ecosystem Services (US $33 trillion). As the authors suggest, this is merely a "snapshot" of the situation at a specific time. In addition, sustainability here is coined as "ecological sustainability" and enters as one of the general goals of the framework and is further operationalized as the "sustainable use level of Ecosystem Functions that should be provided indefinitely and simultaneously" (Constanza et al., 1998: 258).

DeGroot (2002) presents a more systematic approach to Ecosystem Services. He provides a more detailed list of Ecosystem Services and he additionally categorizes and separates Ecosystem Services from "*Ecosystem Functions*" and "*Ecosystem Structure and Processes*". Hence, the first step of analysis is the categorization of "*Ecosystem Functions*" (the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly (DeGroot, 2002: 394) into 4 groups (Regulation, Habitat, Production and Information) and based on that a list of the main Ecosystem Services and Goods is presented. Sustainability here enters as a prerequisite of Ecosystem Services so that "*Ecosystem Functions*" can be maintained (Ecological Values in Figure 5-1) and is understood as ecological sustainability, defined as "*the natural limits set by the carrying capacity of the natural environment, so that human use does not irreversibly impair the integrity and proper functioning of its natural processes and components*" (DeGroot et al., 2000). Nevertheless, it does not undermine the threefold challenge of Daily (1997).

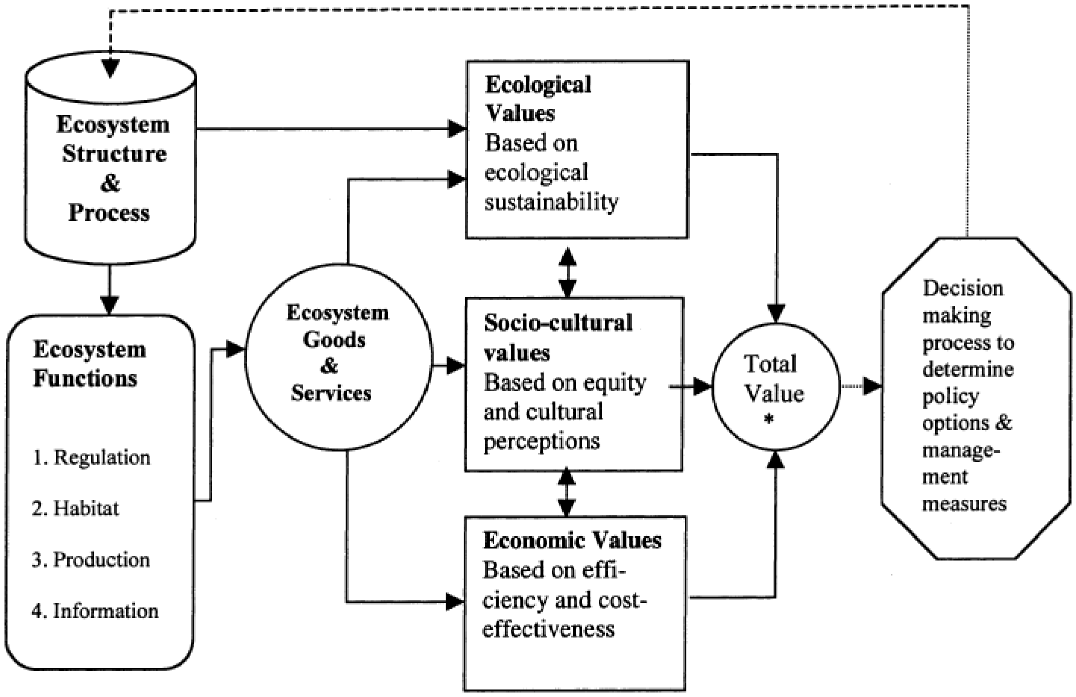


Figure 5-1 : Framework for integrated assessment and valuation of ecosystem functions, goods and services Source:: DeGroot, 2002.

5.2 Ecosystem Services Framework: Practical Implementation of the Framework

The Millennium Ecosystem Assessment (MA) has been hailed as one the first ambitious research efforts on the investigation of the role of Ecosystem Services to human well-being (Carpenter et al., 2009; Layke, 2009). Coordinated by the United Nations, it constitutes a transdisciplinary international effort that presented a conceptual framework of Ecosystem Services and well-being. More specifically, MA aspired to assess the consequences of ecosystem change to human calls and provides policy options so as to prevent and remedy any harmful environmental consequences that are putting the fulfilment of basic human needs in danger (MA, 2005).

The most utilised definition of Ecosystem Services derives from that Assessment and it is described as the "*benefits people obtain from ecosystems*" (MA, 2003: 3). The definition integrates and analyses the role of well-being and how this is related to the provision of Ecosystem Services. MA focuses mainly on human well-being as it seen as one of the means that will contribute to the achievement of Millennium Development Goals (MDGs).

MA provides firstly a two-pillar model where the correlation between Ecosystem Services and human well-being is presented (Figure 5-2).

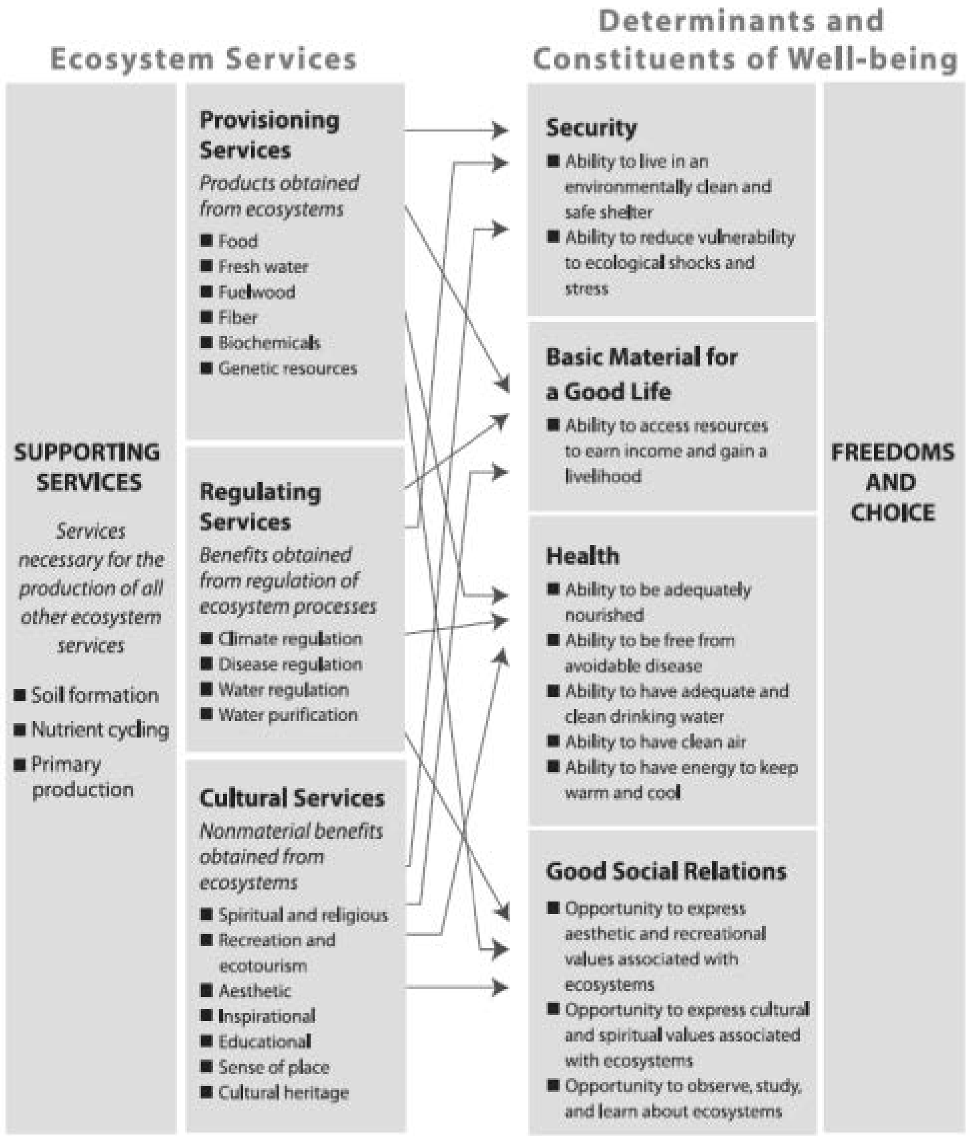


Figure 5-2: . Ecosystem Services and Determinants and Constituents of Well- Being. Source :MA, 2003, p.5.

Such a representation is similar to the framework presented by DeGroot (2002). However, in MA, human well-being and specifically the basic needs of an individual are more than ever emphasized. The framework is further elaborated with addition of direct and indirect factors that alter an aspect of an ecosystem (direct/ indirect drivers) and are separated into two groups (Figure 5-3.).

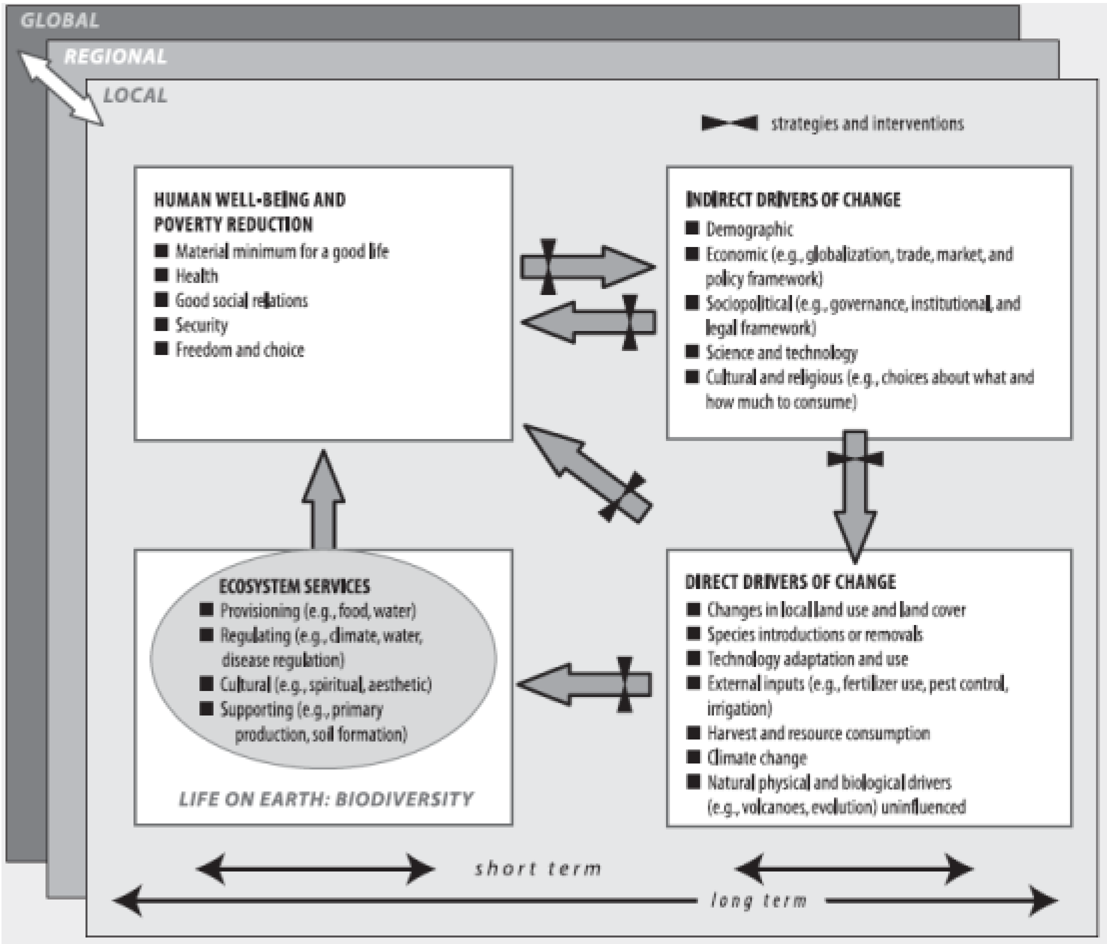


Figure 5-3: MA Conceptual Framework. Source : MA, 2003, p. 9.

Sustainability, i.e. the non- attainment of sustainability, is identified as one of the main challenges for the future and leading to its need to be immediately addressed. As it was stressed earlier, MA is trying to establish a direct dynamic interaction between human well-being and ecosystems. For that reason, it is advocated that sustainable human interaction can assist in reaching human well-being (MA, 2003: 28). And ,as a corollary, the term "*ecological security*", in other words the minimum level of ecological stock needed to ensure a sustainable flow of Ecosystem Services, is employed. Such a term is not something new as it is already allegedly known to be used with terms such as Safe Minimum Standards (Ciriacy- Wantrup, 1968) or Critical Natural Capital (Ekins, 2003).

To put it differently, MA does not define sustainability "narrowly" but in a more general context. By "narrowly" one refers to the "ecological sustainability" as it was defined by DeGroot (2002). On the contrary, MA uses the term in the context of sustainable development and more specifically of the Brundtlandt's definition. Because of that assumption, the linkages between Ecosystem Services and well-being can justify the term "*equitable and sustainable well-being*" that is employed in MA (MA, 2003: 73).

The publication of MA initiated a drastic development in the field of Ecosystem Services and has fuelled a number of collaborative and transdisciplinary research efforts. Based on the lessons learnt by the MA as well as the constructive critique that has been made (Carpenter, 2009; Daily et al., 2009; Layke, 2009), those efforts have tried to revise the MA conceptual framework without losing touch with its basic principles.

The Economics of Ecosystems and Biodiversity (TEEB) constitute one of those collaborative efforts. Firstly, TEEB criticizes the MA for not paying enough attention to the economics of the ecosystems, namely the valuation question, the original aims of the ES concept. A similar notion of Ecosystem Services and Ecosystem Functions is introduced, where Ecosystem Services are defined as "the direct and indirect contributions of ecosystems to human wellbeing" and as "a subset of the interactions between ecosystem structure and processes that underpin the capacity of an ecosystem to provide goods and services" (Kumar and Kumar, 2011). TEEB presents an elaborated version of MA and in its conceptual framework a similar approach to that of DeGroot (2002) is used. More specifically, 4 groups of Ecosystem Functions and 4 groups of Ecosystem Services are identified (Figure 5-4), while well-being is identified by three pillars.

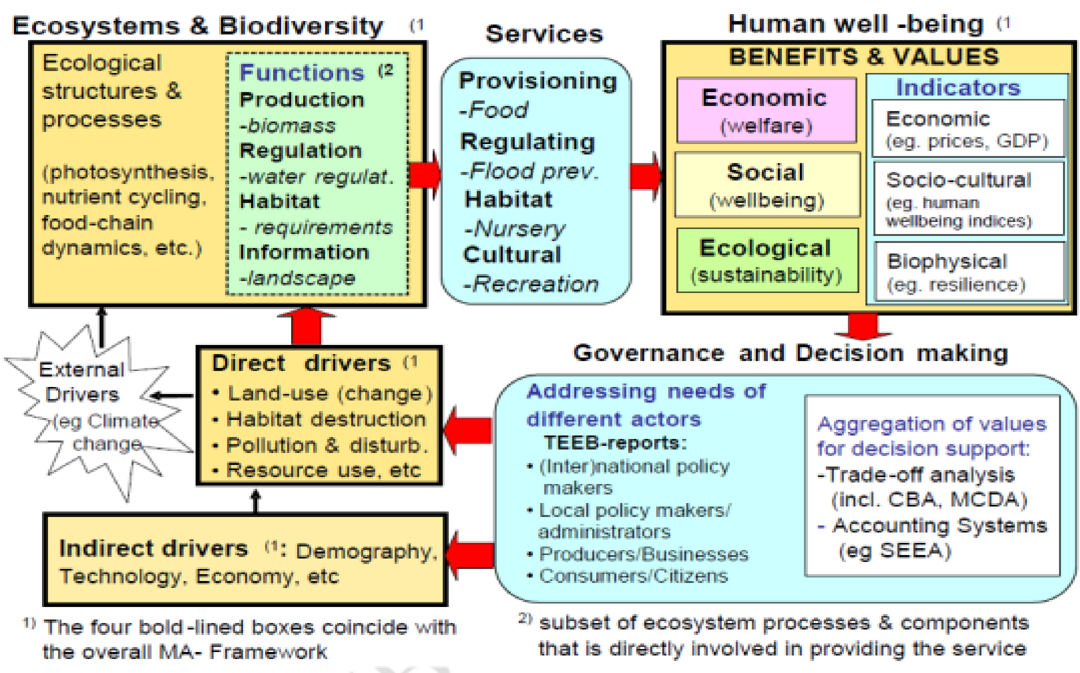


Figure 5-4: TEEB Conceptual Framework for linking Ecosystems and Human Well Being Source: Kumar and Kumar, 2011, p.15.

Sustainability enters TEEB in a more operational sense as its focus is on the valuation of Ecosystem Services. Nevertheless, it cannot be argued that sustainability is undermined. Sustainability is added in the premises of TEEB and is transformed into terms such as carrying capacity and resilience thinking. Apart from that, the report itself proclaims that it embraces a strong sustainability framework (Kumar and Kumar, 2011: 11).

TEEB based its economic analysis and focus on a previous paper by Fisher et al. (2008). The paper proposed a simple but very challenging framework for Ecosystem Services. The main argument was that although the MA heuristic tool is a useful addition to the research, it could lead to confusion as far as the valuation of Ecosystem Services is concerned. This stems from the interrelated nature of Ecosystem Services, where two or more Ecosystem Services can contribute to one specific benefit to human beings (Fisher et al., 2008). So as to avoid such a "double counting" a theoretical framework is provided that builds on previous contribution by Pearce (2007). According to that approach, Ecosystem Services are generally defined as the aspects of ecosystems utilized to produce human well-being. Based on that definition, a distinction between intermediate and final services is necessary. By forming those groups, "double counting" can be avoided. In that sense, only the benefits generated by the final services should be aggregated. A schematic representation of intermediate, final services as well as benefits is presented in Figure 5-5.

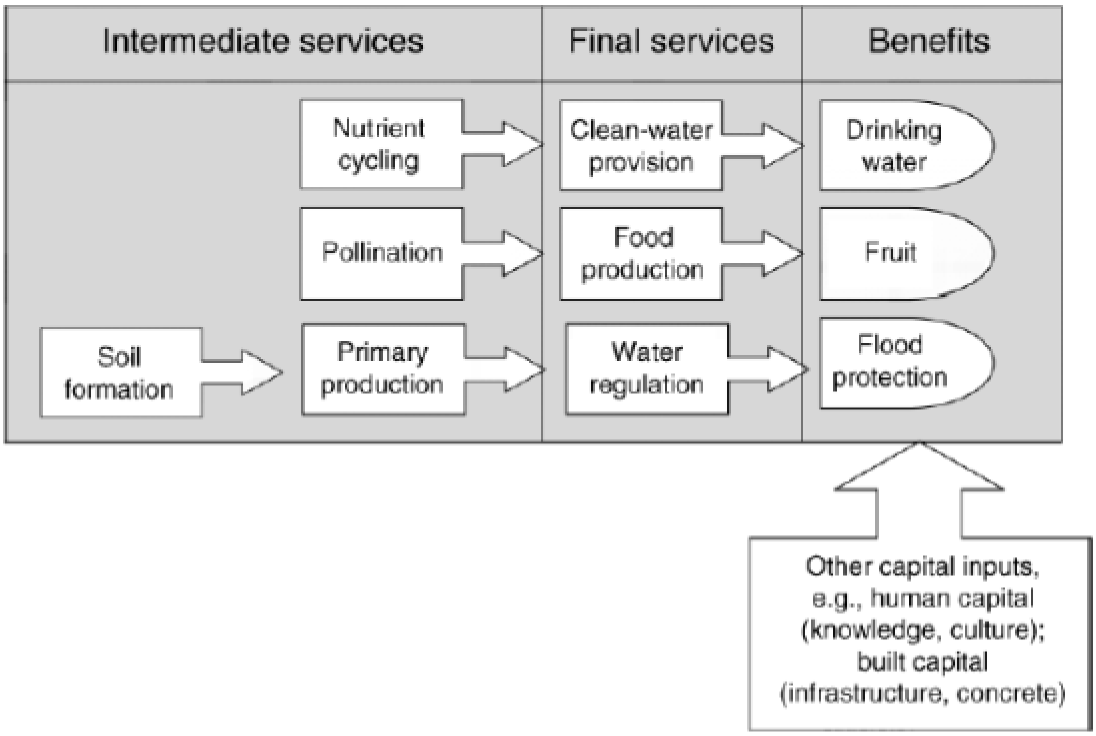


Figure 5-5: The relationships between intermediate, final services and benefits to human well-being . Source: Fisher et al., 2008.

Another aspect of sustainability is its embodiment, in the narrow sense, in using the notion of Safe Minimum Standards (SMS). Acknowledging the uncertainty of ecosystems, it is emphasised that the definition of the SMS zone is one of the main challenges. This zone is understood as "the minimum level of a well- functioning system" so as to provide sustainable flows of ES in a specific ecosystem.

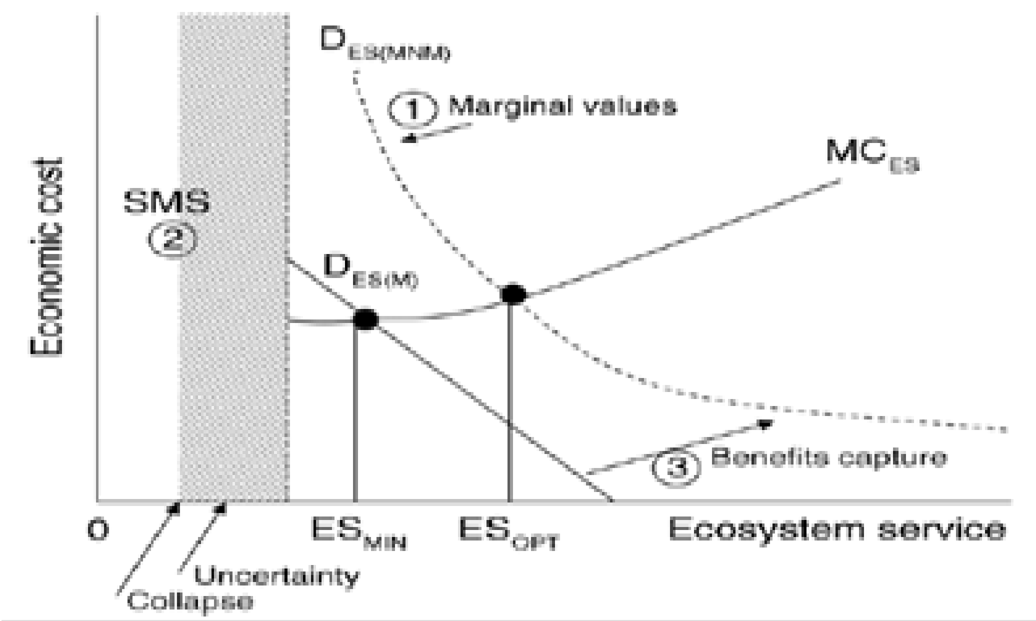


Figure 5-6: Economic Conceptual Framework of Ecosystem Services. Source: Fisher et al., 2008.

Further approaches (Daily and Kareiva, 2011) are adopting already mentioned theoretical foundations for sustainability. It seems that the question of sustainability has been exhausted i.e. adequately answered. This does not suggest, however, that sustainability is neglected or left in the background. Nevertheless, research efforts like that of the Natural Capital Project (Kareiva et al., 2011) or the Common International Classification of Ecosystem Services (CICES) (Haines-Young and Potschin, 2010) are aiming at "clinically" operationalizing sustainability. More particularly, CICES stresses the need for creation of a certain classification scheme for a better systematization, cross-reference and comparison of different outcomes in different regions of the world (Haines-Young and Potschin, 2010). CICES builds up on previous research efforts such as SEEA2003 (The System of Environmental-Economic Accounting initiated by the United Nations Statistical Commission. For more s. SEEA, 2003). There three types of functions are identified (resource, sink, service) and are seen as essential for long-term sustainable development. The updated version aims to correlate those functions with the corresponding services and goods. Although the analysis is based on the TEEB framework, it proposes a more complex but flexible classification and it should form generic categories "*that will be linked in a nested hierarchy so as to accommodate different scales of concern or thematic content*" (Haines-Young and Potschin, 2010: 9).

Following a similar pattern, Seppelt et al (2012) provided a blueprint for Ecosystem Services Assessment which it was based on existing reviews and studies. Different approaches were put in four categories based on two criteria: the objective (theoretical or practical) and the methodological approach (data- based or top-down). Recognising the gap on a number of questions for Ecosystem Services, the blueprint aspired to help further research on the field of Ecosystem Services.

Beyond theoretical approaches, an institutional arrangement was the one that established the role of sustainability with Ecosystem Services. This took place in the Ecosystem Services Partnership 2010 Conference in Salzau, Germany. The “Salzau Message” was declared and signed. In its basic principles the “Salzau Message” acknowledges the need for a sustainable well-being through sustaining and restoring Ecosystem Services and natural capital (Burkhard et al., 2012). “Salzau Message” sets the agenda for the further development of Ecosystem Services Assessment and it can be understood that 5 years after the MA, Ecosystem Services are well integrated in the global environmental policy agenda and are ready to be deployed and implemented for the attainment of sustainable human well-being.

A further concept that distances itself from the aforementioned scientific methods is the framework provided by Grunewald et al. (2012), which has been known as the EPPS Framework (derived from Ecosystem Properties, Potentials and Services) . The framework is based on the TEEB scheme and takes the knowledge of various schools of landscape ecology and the international scientific discussions into account (Grunewald and Bastian, 2015). According to this, the functions’ in the sense of ecosystem integrity are directly attributed to the left pillar (properties of ecosystems), while the societal functions are subsumed in the ES. This better corresponds with the German understanding of the term “*function*”. In the cascade model of Haines-Young and Potschin (2009), functions represent their own intermediate step between the structure and processes on the one side and the ES on the other side. This subgroup of ecosystem processes is essential for and directly contributes to the generation of ES (Albert et al. 2012). The potentials of an ecosystem (or a landscape) show its performance and possible utilisation and, thus, are a logical intermediate step between the properties (structure and processes) and the ES themselves (real use of nature and landscape, or demand). This conceptual concept is called EPPS framework (Grunewald and Bastian 2010; Bastian et al. 2012b).

Ecosystem Properties are located on the left side of the EPPS framework. These are defined as the properties of ecosystems–individual objects, parts of objects and even entire ecosystem complexes–and the structures and processes (e.g. soil qualities, nutrient cycles, biological diversity), which form the basis for all ES and, for the existence of humans and of human society in general. According to van Oudenhoven et al. (2012), ecosystem properties are “*the set of ecological conditions, structures, and processes that determine whether an ES can be supplied*”. Since this ecological endowment is, first of all, scientifically based, it has to be assigned mainly to the factual level. This can be primarily provided by defining indicators. One category of indicators is bioindicators: organisms, whose living functions can be correlated with certain environmental factors in such a manner that they can be used as a specific indicator for them. As indicators may simplify information and present it comprehensively, they enable decision-makers to give convincing reasons for their decisions. Valueless categories like complexity, diversity, rarity, ecosystem integrity, ecosystem health or resilience also belong to the category of “*ecosystem properties*” (De Groot et al., 2002). Such approach also resembles the concept of “*ecological integrity*” that "*describes the maintenance of those structures and processes that is necessary for the ecosystems*" and can be considered as a prerogative for the ES supply (Burkhard et al., 2009).

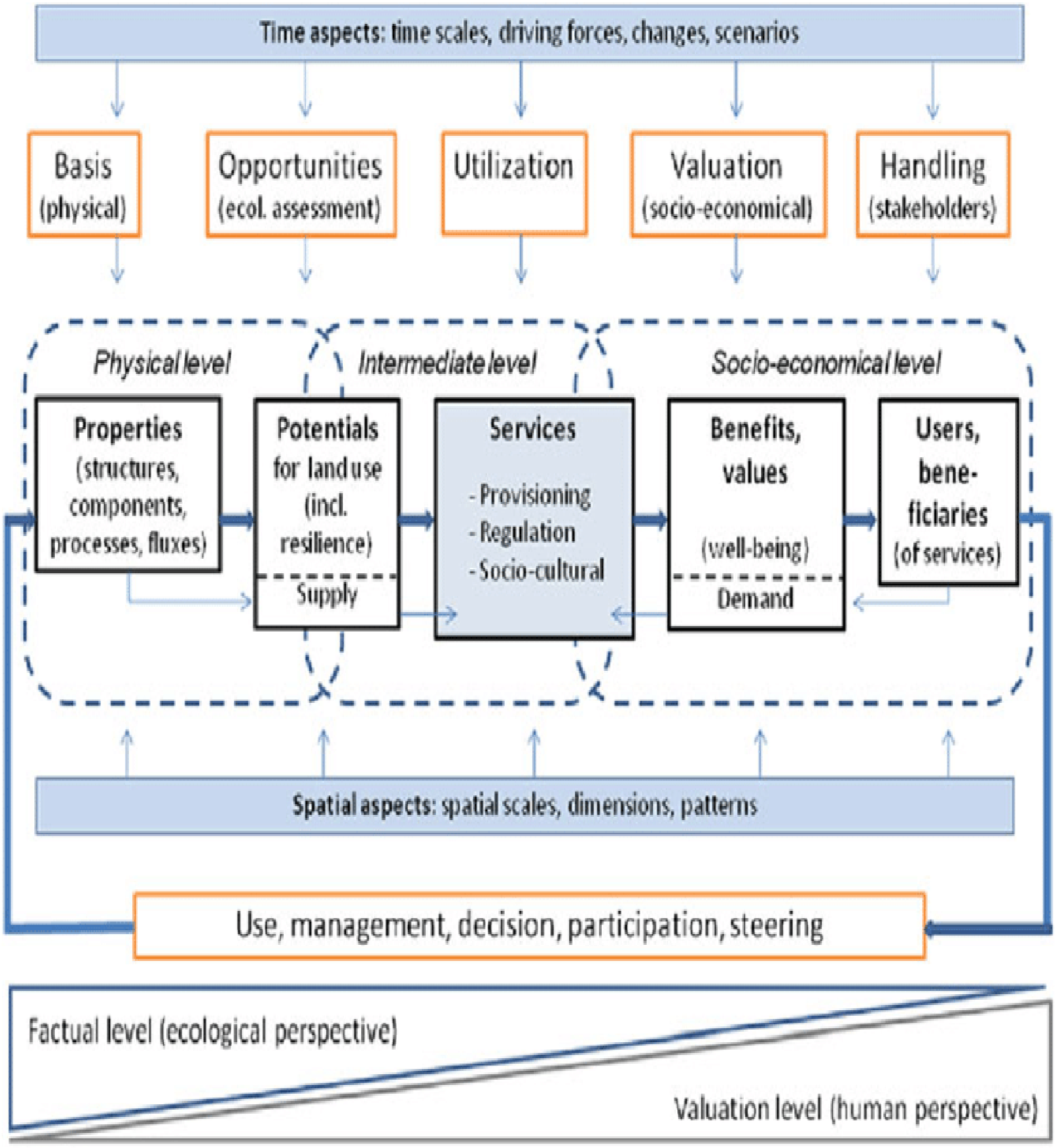


Figure 5-7: Conceptual framework for the analysis and evaluation of ES with a particular focus on space and time aspects . Source: Grunewald and Bastian 2014

Ecosystem Potentials–The Capacity/Supply Side. Potentials have consciously been inserted as the second pillar, so as to distinguish between the possibility of use and an actual use (Bastian et al. 2012a). Potentials can be regarded and quantified as stocks of ES, while the services themselves represent the actual flows (Haines-Young et al., 2012). In terms of ecosystem potentials, various preconditions need to be considered, such as the ecological carrying capacity and the resilience, which is defined as "*the capacity of a system to absorb* *and utilize or even benefit from perturbations and changes that attain it, and so to persist without a qualitative change in the system*" (Holling, 2010).

> ***Resilience or Ecological Stability?***
>
> "*Resilience is closely related to the ecological stability, i.e. the persistence of an ecological system and its capacity to return to the initial situation after changes. Within the 'stability', we can distinguish between constancy and cyclicity (without extraneous factors), as well as between resistance and elasticity (with extraneous factors). In this regard, the carrying capacity, meaning the range of a possible use should be mentioned. It indicates to which extent particular utilizations may be tolerated. Furthermore, the assessment of ecosystem potentials aims at ascertaining the potential use of particular services, and is more normative than a mere accounting of ecosystem properties. It constitutes an important basis for planning, e.g. for the implementation of sustainable land-use systems: the suitability of an ecosystem to carry different forms of land use can be established, the available but still unused potentials can be put to actual use, and risks can be estimated".*

Box 5-1: The Dilemma of Resilience and Ecological Stability. Source: Grunewald and Bastian, 2015:38.

Ecosystem Services. Only human needs or demands actually convert a potential into a real service. ES, the third pillar of the framework reflecting an even stronger human perspective (value level), since the services (and goods) are in fact currently valued, demanded, or used. In other words, the status of an ES is influenced not only by its provision of a certain service, but also by human needs and the desired level of provision for this service by society, which connects inseparably supply and demand of ES (Burkhard et al., 2012; Syrbe and Walz, 2012).

Services and (societal) functions are regarded as synonyms. The term "function" stands for a benefit-oriented view, not for the functioning of ecosystems in the sense of processes, cycles, etc. A tripartite classification of functions (Bastian and Schreiber, 1999) or ES (Grunewald and Bastian, 2010): provisioning, regulation and sociocultural services. The analysis of ES always involves a valuation step, e.g. scientific findings (facts) are transformed into human driven value categories. The crucial factor is the combination of the various causal areas in the relationship between society and nature, one example being economic valuation (e.g. Costanza et al. 1997; Spangenberg and Settele 2010).

Intact ecosystems provide a wide variety of ES that are characterized by complex interrelations (trade-offs, see below). Some ES are strictly related or occur in bundles and, therefore, are influenced positively or negatively if a particular ES is enhanced (e.g. the maximization of the yield of an arable field at the expense of regulation ES, like carbon sequestration, or habitat services). The manner of connections and interrelations between single ES is still an issue with significant knowledge gaps (MA 2005).

Nevertheless, negative social or economic effects of ecosystems (and landscapes) to human well-being, so-called "*disservices*" (Lyytimäki and Sipilä, 2009; Dunn 2010) are also taken into consideration. The term ES is only justified if ecosystems and their processes create a benefit for humans. Status and value of ES are determined by the demand depending on the societal conditions. The actual land use reflects such a demand. For the application of the ES concept, the demand side plays a crucial role. Suitable data is often only available to a limited extent. They must be specifically collected, which mostly entails a significant amount of work (Grunewald and Bastian, 2015)

Benefits, Values and Welfare. Through the ES link, human beings benefit from ecosystems. In other words, ecosystems yield benefits and values (fourth pillar of the EPPS framework), which contribute to human well-being. The benefit is the sociocultural or economic welfare gain provided through the ES, such as health, employment, and income. Moreover, the benefits of ES must have a direct relationship to human wellbeing (Fisher and Turner, 2008). Value is most commonly defined as the contribution of ES to goals, objectives or conditions that are specified by a user (van Oudenhoven et al. 2012). Actors in society can attach a value to these benefits. Monetary value can help to internalize so-called externalities (impacts and side effects) in economic valuation procedures so that they can be better taken into account in decision-making processes at all levels. It should be noted once more that not all dimensions of human well-being can be expressed in monetary terms, e.g. cultural and spiritual values.

An evaluation step is necessary In order to measure benefits and values,. Generally, an evaluation is a relation between an evaluating subject and an object of evaluation, or the degree of fulfilment in comparison with predetermined objectives. This relation has two dimensions (Bastian and Grunewald, 2012): Factual dimension, i.e. facts on the object to be evaluated for the reflection of the reality and the Value dimension, i.e. value system or basic values as a normative basis for the value judgment (Bechmann 1989, 1995)

Beneficiaries of ES/Actors. An ES is only a service if there is a human benefit. Without human beneficiaries, there are no ES (Fisher et al. 2009). Accordingly, a disservice only exists if humans suffer harm. The stakeholders, providers, users or beneficiaries of ecosystems and their services can be single persons, groups, or society as a whole. Not only do they depend or benefit from ecosystems, they in turn react upon ecosystems through land use, management, decision, regulation, etc.

The identification of beneficiaries of ES helps to develop environmental-political steering instruments to set incentives in a targeted manner for a more careful management of ecosystems and the services they deliver. The key question is: Who benefits where from which ES? The following cases can be distinguished (Kettunen et al. 2009):

- Local public benefits: a site's role in supporting local identity, local recreation, local nonmarket forest products and the local 'brand', etc.

- Local private benefits: a site's support to natural water purification resulting in lower pre-treatment costs to the local water supply company, etc.
- Local public sector benefits: a site's abilities to mitigate floods resulting to lower public investment in flood control and/or flood damage, etc.
- Regional and cross-border benefits: regulation of climate and floods, mitigation of wild fires, provisioning and purification of water in transnational river basins, etc.
- International/global public benefits: a site's provision of habitat for a migratory species at some point in its annual cycle, regulation of climate (carbon capture and storage), maintenance of global species and genetic diversity, etc.
- International private benefits: new pharmaceutical or medicinal product derived via bioprospecting, etc.

Trade-Offs, Limit Values, Driving Forces and Scenarios. Other very important points of view regarding ES are related for example to the so-called trade-offs. They describe the multiple interactions and linkages among services; this means that management aimed at providing a single service (e.g. food, fibre, water) often reduces biodiversity and the provision of other services (Ring et al. 2010). Some ES co-vary positively but others negatively. For example, the increase of provisioning ES may reduce many regulation ES. Thus, the growth of agricultural production may reduce carbon storage in the soils, water regulation and/or sociocultural ES. The TEEB study (TEEB 2009) distinguishes between:

- Temporal trade-offs: Benefits now–costs later,
- Spatial trade-offs: benefits here–costs there,
- Beneficiary trade-offs: Some win–others lose,
- Service trade-offs: Enhancing one ES–reduces another.

All pillars or categories of the framework can or should be analysed and differentiated in terms of space (e.g. scale, dimension, patterns) and time (e.g. driving forces, changes, scenarios) aspects.

If critical thresholds or limit values are exceeded, substantial changes are expected. Ecosystem changes can be triggered by various driving forces. Artner et al. (2005) distinguished between fixed factors or drivers, e.g. the ongoing globalisation, the demographic change and variable factors like the economic development, the societal governance, leisure behaviour, the traffic volume, the consumption of resources and the structural development. The status of ES can be predicted or analysed under the assumption of different scenarios. A set of scenarios can be used to simulate possible long-term effects and consequences of decisions (Dunlop et al. 2002). Scenarios inform the decision-maker about possible welfare gains and losses. Not only do the changes in ecosystems and ES have to be considered, but also the variability of values. Value orientations are subject to cycles and trends. The future development of societal values depends on many factors. As the value scales, for example the value of money, may change, monetary valuations of future states are subject to considerable uncertainties.

But apart from those contributions concerning the development of Ecosystem Services, it would be interesting to look at a specific critique concerning the mature phase of Ecosystem Services and how they are mainstreamed to the policy agenda. Farley (2012) underlines characteristically some key surrounding Ecosystem Services and sustainability. It is merely a constructive criticism to the existing framework of Ecosystem Services. Farley pays specific attention to sustainability as well as that of justice and efficiency. He argues that Ecosystem Services are essential for human welfare; however the insistence for marginal analysis and monetary valuation should be seen as one-way (Farley, 2012). This seems a logical argument and existing research seems to adopt such a stance. Despite the fact that almost all projects are putting the valuation question at the centre, it is noted that this is sometimes impossible and for this reason biophysical units can be adopted (Kareiva et al., 2011; MA, 2003).

5.3 Analysing the Ecosystem Services Framework. Theoretical and Practical Aspects

Two specific traits of the ES framework may be considered as an invaluable addition and interpretation of well-being and sustainability. On the one hand, the well-being is directly framed as the primary goal of the Framework. On the other hand, the attainment of well-being is succeeded by measuring the status of the ecosystems. Consequently, well-being is directly correlated with the environment and its current and future status. Defining well-being in all theoretical ES approaches have an input of aforementioned theories and concepts such as that of Sen (1999) and Nussbaum (2011). Nevertheless, the centre of attention is twofold. Firstly, targeting at human well-being has been seen through the help of ES, as flows of services are translated as benefits to humans. Secondly, the environment should be seen as the habitus, i.e. “oikos” of human beings, therefore well-being attainment is contingent on the situation of the environment (stocks) and their supply (flows).

Additionally, the EPPS framework presents an interesting trait that again has been referred to above. This is the trait of “potential”, which is here seen as the potential of an ecosystem to provide ES. This is the same mechanism that lies behind the Sen’s Framework (1999) that considers capabilities, i.e. what an individual can potentially achieve, in contrast to the functionings. This notion is transferred to ecosystem in the ES Framework, stressing the need of focusing on potential, i.e. what an ecosystem can possibly supply, as in many cases, the ecosystem can provide those potential services in the future and/or offer an augmented/ reduced level of existing ES.

Furthermore, one should look at how sustainability is integrated in the ES framework. This is basically encrypted in the way ES are categorized. Beyond MA, other ES framework concepts are “limited” to defining three basic categories of ES. If one looks at them carefully, one could find a direct interpretation of the three pillar model of sustainability. This means that regulating services corresponds to ecological sustainability, provision services to economic sustainability and finally cultural services to social sustainability (Grunewald and Bastian, 2015). Therefore, by assessing the different categories of ES, one can also estimate the situation of sustainability partially or as a whole.

It is understandable that ES can provide a sufficient concept where the concept of well-being along with the concept of sustainability can be successfully integrated. Consequently, the aim of the next chapter is to articulate those theoretical implications with a practical example.

One of the primary goals of the ES framework is the valuation of ES. This can be seen as the realm of economists. Despite the fact, that one expects, from an economist to provide solely monetary values for each ES, the scientific debate on that matter dates long before the creation of ES. Grunewald and Bastian provide a comprehensive and extensive overview of that matter.

"The evaluation shows the extent to which the present state differs from the desired or planned one (Auhagen 1998). The literature often uses the term 'evaluation' ambiguously (Wiegleb 1997), e.g. in the sense of basic assessment (scaling), judgment, ranking (relative comparison), or plan/actual comparisons (= evaluation sensu stricto). An evaluation is the crucial step to process analytical data concerning decision-making and action, i.e. to convert scientific parameters into socio-political categories. An evaluation sensu stricto indicates the extent and the manner of necessary measures. It provides the norms and orientations for the concrete action, which is always a decision between several options. If an evaluation shall be generally valid, the consensus of the human society is necessary; it is a matter of conventions and, thus, depending on the situation and time. Therefore, evaluation can never be objective. The skill of evaluation is the combination of facts and standards of value with sensible judgement. Evaluations are always based on the competence of the evaluating subject. On no account does subjectivity mean arbitrariness or irrationality since an evaluation is or should be also comprehended by other subjects (intersubjectivity). […].

There are quite different motivations behind ES valuation. These motivations heavily depend on moral, aesthetic, and other cultural perspectives (Hein et al. 2006). It is often neglected that scientific findings are in principle free of value. That means that there is no logical conclusion on the desired situation from being. […] Already Hume (1740) referred to the problem of the dichotomy between what is and what ought to be. As a term for the derivation of norms from nature, Moore introduced the term 'naturalistic fallacy' in his 'Principa Ethica' in 1903. Terms like naturalness, rarity, etc. don't necessarily prejudge a value decision. The protection of rare species must be justified because not all rare things are per se worthy of protection. […].

The sense of formalized evaluation algorithms is to rationalize the (landscape) planning process and to increase the acceptance of the results by society. For the analysis of benefits and values in the ES context, monetary valuation is often regarded as the method of choice. The sole orientation to the monetary valuation of ES, however, is increasingly regarded critical (Spangenberg and Settele 2010). On the other side, studies on the implementation of measures and their financial consequences (e.g. Lütz and Bastian, 2000; von Haaren and Bathke 2008; Grossmann et al. 2010), have shown that a monetary valuation of services may provide incentives for alterations in existing management rules or decision support for certain problem solutions. Monetary values served to internalize so-called externalities (external influences, impacts) in economic valuation methods in order to take them better into account in decision processes at all levels. In addition to the economic evaluation, other approaches must also be observed to show the importance of ES. Other dimension of human well-being that cannot be expressed in monetary values, e.g. cultural and spiritual values, should also be integrated. Participative methods have a great significance.. The preferences for certain ES are negotiated within society. As a basis, adequate background knowledge is indispensable. In principle we distinguish between three types of methods for the evaluation of ES: quantitative expert methods, economic/monetary methods and participative, scenario-based methods.

Box 5-2: Evaluating ES: A first introduction. Source: Grunewald and Bastian, 2012.

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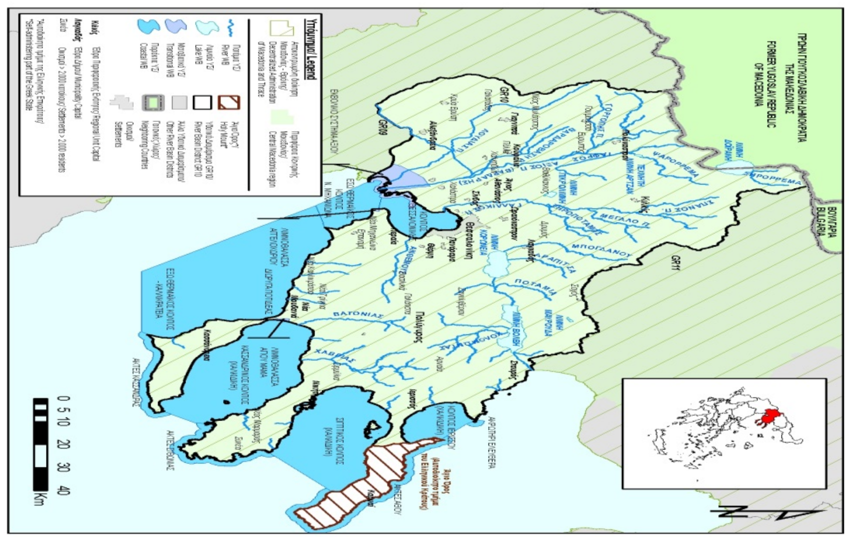
Chapter 6: Putting Ecosystem Services into Practice: The Case of the Water Districts of Central and Western Macedonia



Chapter 6: Putting Ecosystem Services into Practice: The Case of the Water Districts of Central and Western Macedonia

6 Ecosystem Services into Practice

This chapter is basically focused on the practical application of ecosystems services. The main aim of this chapter is to provide a case study example of how ecosystem services can be assessed and monetary valuated. Within the frame of the Water Framework Directive (WFD), all Member States are obliged to compose Water Basin Management Plans (WBMP). These management plans will be the basic reference, based on which the "translation" into ecosystem services will take place.

The chapter begins with a short introduction of the Water Framework Directive. Afterwards, the basic theoretical framework will be presented. This is merely based on the works by Koundouri et al. (2016) and Grunewald et al. (2015). Both authors suggest a concept, with which Water Basin Management Plans can be reformulated so as to provide the basis of bringing Ecosystem Services into practice.

The main part of the chapter is dedicated to a thorough economic valuation of water ecosystem services in the Water Districts of Central and Western Macedonia. The primary research has been conducted within the frame of composing the Water Basin Management Plans for the aforementioned water districts and more specifically the economic valuation and cost recovery ratio for all water uses. The next step is to use those values so to assess the value of specific water-related ecosystem services. This analysis is the first of its kind Greece. Apart from that, the author was involved in the primary research. Therefore, after the analysis a critical review of the values along with a critique of the theoretical concept will follow.

This chapter aims at presenting a more extensive view of bringing ecosystem services to policy making. The main question of the chapter is basically how can ecosystem services can be applied in practice, how can existing concepts and policies can help formulate the value of ecosystem services and how can be this be used further for policy making.

Chapter 6: Putting Ecosystem Services into Practice: The Case of the Water Districts of Central and Western Macedonia

6.1 The Water Framework Directive and its implications for economic assessment

The Water Framework Directive (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities in 2000. This Directive is the result of a long process of more than five years between a wide range of experts, stakeholders and policy makers. This process points out "*the widespread agreements on key principles of modern water management that today form the foundation of the Water Framework Directive*" (WATECO, 2002).

The Directive establishes a framework for the protection of all water bodies (including inland surface waters, transitional waters, coastal waters and groundwater) which:

- Prevents further deterioration of, protects and enhances the status of water resources;
- Promotes a sustainable water use based on long-term protection of water resources;
- Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and
- Contributes to mitigating the effects of floods and droughts.

All in all, the Directive aimed at achieving good water status for all waters by 2015 (WATECO, 2002).

The WFD foresaw an initial timetable of key actions needed to be undertaken. These are the following (WATECO, 2002).

- Identification of the individual river basins lying within their national territory, their assignment to individual River Basin Districts (RBDs), and identification of competent authorities by 2003 (Article 3, Article 24);
- Characterisation of river basin districts in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the river basin district, by 2004 (Article 5, Article 6, Annex II, Annex III);
- Realisation of the inter-calibration of the ecological status classification systems by 2006 (Article 2(22); Annex V);
- Monitoring of water status by 2006 (Article 8);
- Identification by 2009 of a programme of measures for achieving the environmental objectives of the Water Framework Directive cost-effectively (Article 11, Annex III);

- Publication of River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (Article 13, Article 4.3);
- Implementation of water pricing policies that enhance the sustainability of water resources by 2010 (Article 9);
- Introduction of the measures of the programme 2012 (Article 11); and
- Implementation of the programmes of measures and achievement of the environmental objectives by 2015 (Article 4).

Furthermore, WFD aspires to integrate economic analysis into water management. For that reason, economic analysis fulfills several different functions in the WFD. These are the following (WATECO, 2002):

- Composition of an economic analysis of water uses in each River Basin District;
- Assessment of trends in water supply, water demand and investments;
- Identification of areas designated for the protection of economically significant aquatic species;
- Designation of heavily modified water bodies based on the assessment of changes to such water bodies and of the impact (including economic impact) on existing uses and costs of alternatives for providing the same beneficial objective;
- Assessment of current levels of cost-recovery;
- Support for the selection of a programme of measures for each river basin district on the basis of cost-effectiveness criteria;
- Assessment of the potential role of pricing in these programmes of measures– implications on cost-recovery;
- Estimation of the need for potential (time and objective) derogation from the Directive’s environmental objectives based on assessment of costs and benefits
- and costs of alternatives for providing the same beneficial objective;
- Assessment of possible derogation resulting from new activities and modifications, based on assessment of costs and benefits and costs of alternatives for providing the same beneficial objective;
- Cost evaluation of process and control measures to identify a cost-effective way to control priority substances.

Table 6-1 presents the economic elements of the WFD as these are integrated in the legal document.

Table 6-1: Overview of the Economic Elements in the WFD. Source: WATECO, 2002.

Reference	Summary Provisions
Preambles 11, 12, 31, 36, 38 and 43	• That the polluter should pay; • Take into account the economic and social development of the Community; • Lower objectives justified if unreasonably expensive to achieve good status; • Carry out an economic analysis of water uses; • Use economic instruments as part of the programmes of measures; • Apply the principle of cost recovery of water services (including environmental and resource costs) in accordance with the polluter pays principle; • Identifying cost-effective combination of measures for reducing pollution of priority substances.
Article 2: Definitions 38 and 39	Definition of water services – Definition of water use
Article 4: Environmental objectives Designation of Heavily Modified Water Bodies (4.3) Environmental objectives and derogations (4.4, 4.5 and 4.7)	An economic justification can be provided for designating Heavily Modified Water Bodies ('....for reasons of technical feasibility and disproportionate costs.... '). Possible economic justification for derogation: • Time derogation if ...completing the improvements within the time scale would be disproportionately expensive...; • Objectives derogation if ... the achievement of these objectives would be infeasible or disproportionately expensive ...and there are no other means which are a significantly better environmental option not entailing disproportionate cost; • Derogation for new modification or sustainable economic activity, if benefits of this activity outweigh benefits from good water status and there are no other means which are significantly better environmental option not entailing disproportionate cost.
Article 5: Characteristics of the river basin district, review of the environmental impact of human activity and economic analysis of water use Annex III: Economic Analysis	As part of the analysis of the River Basin characteristics, an economic analysis of Water uses must be conducted. According to specifications in Annex III, the economic analysis shall contain enough information in sufficient detail to • Make the relevant calculations necessary for taking into account cost recovery of water services, taking account of long term forecasts of supply and demand for water in the RBD and, where necessary: a) Estimates of the volume, prices and costs associated with

	water services: b) Estimates of relevant investment including forecasts of such investments. • Make judgements about the most cost effective combination of measures in respect of water uses to be included in the programme of measures under Article 11 based on estimates of the potential costs of such measures
Article 6: register of protected area & Annex IV: Protected areas	Designation of areas for the protection of economically significant aquatic species.
Article 9: Recovery of costs for water services	Take account of the principle of recovery of the costs of water services, including environmental and resource costs, according to the polluter pays principle Member states shall ensure by 2010 • that water pricing policies provide adequate incentives for users to use water resource efficiently, and thereby contribute to the environmental objectives of this Directive » • An adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services... Possibility to account for social, environmental and economic effects in defining pricing policy
Articles 11: Programme of measures & Annex VI: Lists of measures to be included within the programme of measures	Establishment of programme of measures with references to the analysis performed based on Article 5 (thus, the economic analysis of water use according to Annex III) and including as basic measure (b) measures deemed appropriate for the purposes of Article 9 (i.e. recovery of costs for water services)
Article 13: River Basin Management Plans & Annex VII: River basin management plans	The river basin management plan shall cover: A summary of the economic analysis of water use as required by Article 5and Annex III.
Article 16 "Priority Substances"	Use of cost-effectiveness criteria for identifying best combination of product and process controls for controlling priority substances
Article 23 "Penalties"	Defining penalties may build on economic input, as these penalties have to be ...effective, proportionate and dissuasive.

6.2 Integrating the WFD into the Ecosystem Services Concept: A primary theoretical framework

It can be assumed that the Water Framework Directive (WFD) requires a heavy bulk of research and is basically a long-term process. Nevertheless, this process may serve as a theoretical and practical basis for the evaluation of the ecosystem services.

Currently, there has been a limited number of studies and research that aspire to combine the WFD with the ecosystem services concept. In our research two main studies will be highlighted and be used a basis for integrating ecosystem services in the case study of Central and Western Macedonia.

The first approach, developed by Koundouri et al. (2016) describe a concept that points to the achievement of sustainable and environmental and socioeconomic management of freshwater ecosystem services. The Ecosystem Services Approach lies at the centre of the suggested economic assessment for the implementation of a more sustainable and efficient water management (Koundouri et al., 2016).

The process is broken three steps (Koundouri et al., 2016):

- socio-economic characterization of the River Basin area,
- assessment of the current recovery of water use cost, and
- identification and suggestion of appropriate programs of measures for sustainable water management over space and time.

According to Koundouri et al (2015) *"This methodology is consistent with a) the economic principles adopted explicitly by the Water Framework Directive (WFD), b) the three-step WFD implementation approach adopted in the WATECO document, c) the Ecosystem Services Approach to valuing freshwater goods and services to humans"* .

At the first step, the significant water uses in the respective River Basin are identified, while the ecosystem services that support those uses are defined. At the second step, the current recovery of costs of uses is primarily estimated and at the third step, the economic assessment of potential measures for sustainable water management is finally carried out (Koundouri et al., 2016). More specifically, the third step is graphically described in Figure 6-1. Figure 6-1 depicts two possible scenarios concerning the situation of a River Basin and shows how freshwater is affected when all or no measures are realized. The gap in 2015 shows the economic gap, i.e. the cost of measures needed to be undertaken so as the River Basin achieves the desired level status (Koundouri et al., 2016).

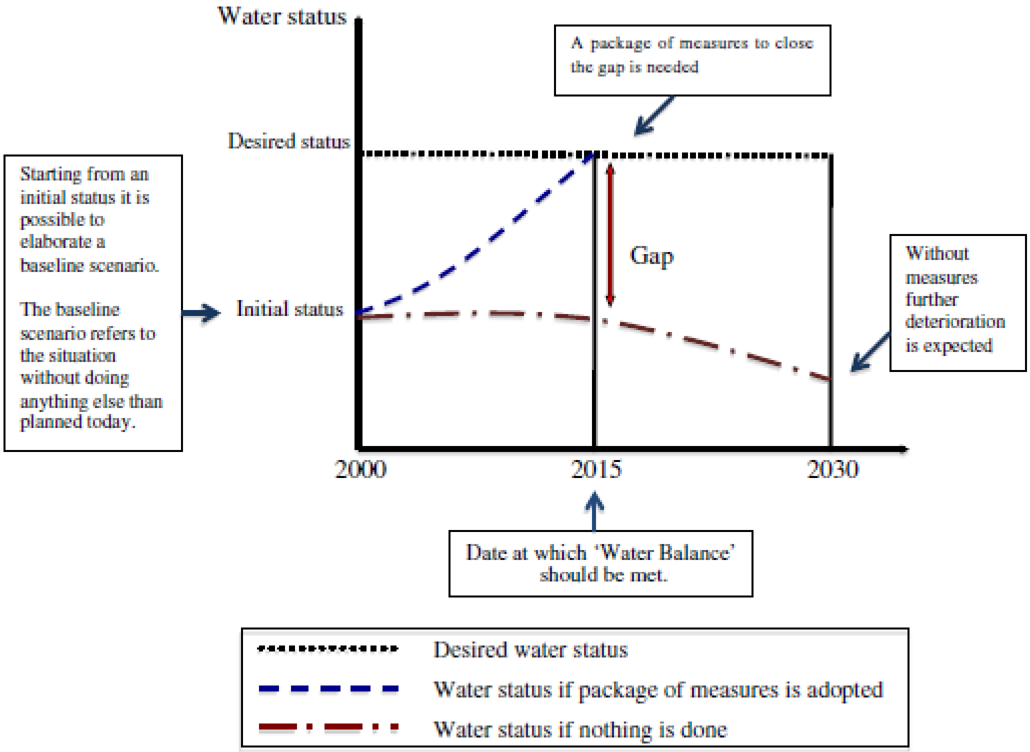


Figure 6-1: Construction and baseline scenario Source: Koundouri and Davila, 2013.

Koundouri et al. (2016) implements the methodology on a specific case study, the Anglian river basin, located within the administrative regions of East of England and East Midlands. The results of this primary assessment are presented in Table 6-2.

Table 6-2: Economic value of four ecosystem services Source: Koundouri et al., 2016.

Category of ecosystem service	Type of service	Average value per person per year (UK, 2013)
Provisioning Service	Drinking Water	€ 28.98
Regulating Service	Water Treatment	€ 24.99
Supporting Service	Erosion Protection	€ 2.82
Cultural and Amenity Service	Habitat for Species	€ 16.95

The second concept builds upon the Ecosystem Properties, Potentials and Services (EPPS) concept described in Chapter 5 (Grunewald and Bastian 2010; Bastian et al. 2012b). The aim is basically to link the WFD research process with the Ecosystem Services Concept and identify the cohesion between these two concepts. Grunewald et al. (2015) consider WFD as an excellent example of how ecosystem services can be analysed, while the primary focus of interest is the time and space scale. Although this is not directly correlated with the economic valuation, this preparation is a necessary prerogative so as the economic estimation can be carried out (Bastian et al. 2012b).

Table 6-3: Check list of space and time issues exemplified by WFD and linkage with Ecosystem Services. Source: Grunewald et al., 2015.

Pos.	Issue	Implementation in WFD (examples)	ES–example: Groundwater Recharge
1.	Space Aspects		
1.1	Areal requirements	Minimum sizes of standing waters (50 ha) and catchments (of flowing waters: 10 km2) in the WFD taken into account; catchment alignment instead of administrative units	Mapping areas and state of groundwater bodies
1.2	Spatial composition	Combined consideration of surface and groundwater, management of entire catchments	Mapping groundwater recharge (supply) and groundwater extraction (demand), accounting balance
1.3	Spatial configuration	Configuration issues only partially implemented with mappings of the waters' structure; fish migration ability considered; confined to big- and medium-sized water Bodies (i.e. two-third of streams are not considered in terms of their structure)	Hydrogeological maps, land use, etc.
1.4	General: functional connection	Orientation towards human health, quality of life, joint consideration of biological, chemical and ecological quality	Maps of groundwater protection
2.	Time Aspects		
2.1	Time requirements	Differentiating management measures by graduated time periods	Time aspects of groundwater flows, monitoring (water level gauge)
2.2	Temporal sequences	Targets in accordance with ecological processes are differentiated according to specific time periods; flexible management priorities	Natural conditions can vary (precipitation necessary for water infiltration, crop rotation), trends (e.g. climate change)
2.3	Time lags	Strict application of the precautionary principle, (flood) risk minimisation	e.g. water protection areas
3.	Scale Dimension		
3.1	Suitable dimension	Combined top-down and bottom-up approach, planning and management regional, but measured locally	Hierarchy of catchment areas
3.2	Transition	Partly considered: influences on adjoining	Many local measures

	seas and estuaries as well as effect on climate protection goals– rather good; on floodplains and floods: poor	can effect groundwater recharge regionally (or regarding the whole water body)

With respect to the analysis and evaluation steps as well as to the supply and demand perspectives, not only the ecological aspects are concerned, but also socio-economic and cultural aspects are taken into consideration (Grunewald et al., 2015). Primarily, space and scale effects are related mainly to ecological phenomena. However, the concept aims to widen this perspective and to include socioeconomic aspects as well (Bastian, et al., 2012b).

Additionally, all basic aspects of the ES approach can be found in WFD e.g. conflict relevance, focus on problems, goal setting, environmental and economic data, quantitative and model-based approaches, integrated approach, participatory approaches, decision support systems, cost-benefit considerations, and solutions-oriented approach. Put into the EPPS modified concept, the WFD represents an enormous advance over previous approaches, simply because of clear definitions and conceptual hierarchies. Nevertheless, some of the special questions concerning space, time and scale relationships in ES assessments could be solved and discussed (Grunewald et al., 2015).

6.3 Implementing the Ecosystem Services Concept through the Water Framework Directive (WFD) Economic Assessment

This chapter is dedicated to the presentation of the WFD economic assessment and how this can be "translated" into the ES concept. Based on the theoretical framework presented above, one can assume that total value of water is equal to the cost of two basic ecosystem services. These will be the following:

- Provisioning service (freshwater provision)
- Provisioning service (provision for agricultural water)
- Provisioning service (water for electricity use)

Under the Integrated River Basin Management Plans of the Water Districts of Central Macedonia and Western Macedonia, the deliverables "*Economic Analysis of Water Use and definition of the Cost Recovery Ratio of water services*" and "*Preliminary Proposals for Water Pricing in the Water Districts of Western and Central Macedonia*" were published by the Special Secretariat for Water of the Ministry of Environment, Energy and Climate Change (MEEC) in Greece. Both deliverables were prepared with the contribution of the University Institute of Urban Environment and Human Resources, Panteion University, Athens, Greece. The study was carried during the period June 2012- March 2014. Further details concerning the study will be presented in the chapters below.

Furthermore, it should be noted that some assumptions were made that are different for the concept presented by Koundouri et al. (2016). Nevertheless, the rationale behind those assumptions will be described after the presentation of the WFD economic assessment.

6.4 The case study area: The Water Districts of Central and Western Macedonia

The Water District of Central Macedonia (WD10) has an area of 10.165 km^2, and includes the River Basins of Axios (GR03), Gallikos (GR04), Chalkidiki (GR05) and Athos (GR43).The Water District borders north with FYROM , while river run offs flow southeast of Thermaikos gulf and to the bays between the capes of the Chalkidiki peninsula . All River Basins are under the jurisdiction of the Regional Administration of Central Macedonia. Within the limits of the WD 10 the Regional Administration Units of Chalkidiki and Mount Athos, of Thessaloniki and Kilkis are situated, as well as parts of the Regional Administration Unit of Pella (33%) and Imathia (26%). Under national law, the Decentralized Administration of Macedonia - Thraki, Central Macedonia Water Directorate is responsible for the entire watershed of the WD10 (Ειδική Γραμματεία Υδάτων, 2014c; 2014d).

Extensive plains are situated mainly in the western part of the WD10 (Thessaloniki. Lagadas and Giannitsa) and the area is not considered as mountainous. The average altitude of WD10 is 245m, where 36% of its area has an altitude below 100 m and only 3 % of its area has an altitude of over 800 m. Only Mount Athos (2.033m) and Mount Kerkini (2.031m) have an altitude above 2,000 m.

Its population, based on census data of the Hellenic Statistical Authority in 2001 was 1,356,509 inhabitants, while according to the provisional results of the 2011 census there is an increase of 1% (1,373,830 inhabitants (Ειδική Γραμματεία Υδάτων, 2012).

The average annual rainfall ranges from 400 to 800 mm, while in the mountainous parts exceed 1.000 mm. Snowfall is quite common during the period September-April. The mean annual temperature ranges between 14.5 ° C and 17 ° C with the coldest month in January and warmest in July.

The average annual total water supply to WD10, according to a study by the Ministry of Development (2008), amounts to 5.3 x 10^9 m^3. 28% (1.5 x109 m^3) comes from own resources, while the rest 72% (3.8x10^9 m^3) comes from:

- the water inflow from the neighbouring FYROM (3.3x109m^3 i.e. 87 %);
- the karst aquifer discharge of the Paiko Mountain that is extended beyond the boundaries of Central Macedonia (57x$10^6$$m^3$i.e.1,5%) and;
- the waters of the river Aliakmonas and more specifically the Aghia Barbara reservoir (about 446x10^6 m^3 i.e.12%).

The Water District of Western Macedonia (WD09) is located in the north-western part of Greece and includes the River Basins of Prespes(GR01)and Aliakmonas (GR02). Its area is 13,624 km^2 and it is under the jurisdiction of the Administrative Region of Western Macedonia (65.2 %) and Central Macedonia (33.1%). The former belongs to the Decentralized Administration of Epirus - Western Macedonia and the latter to the Decentralized Administration of Macedonia - Thrace. Parts of the WD09 belong to the

Administrative Regions of Epirus (0.4 %) and Thessaly (1.4 %). In addition, WD09 covers all twelve (12) municipalities of the Administrative Region of Western Macedonia, significant portion of nine (9) municipalities of the Administrative Region of Central Macedonia, part of one municipality of the Administrative Regions of Epirus and parts two municipalities of the Administrative Region of Thessaly (Ειδική Γραμματεία Υδάτων, 2014c; 2014d).

The area of WD09 is mostly mountainous as only 30% of the area of it is below 600m. Main feature is the existence of nine mountain peaks with an altitude of over 2,000 meters with the highest peak in Greece (Olympus Mitikas 2,917m). Apart from that, WD09 is characterized by the existence of two major mountain complexes. The first consists of the mountains Verno (2,128 m) , Askio (2,111 m) and Vourino (1,688 m) , while the second from the mountains north (2,524 m) , Vermio (2,052 m) and Pieria (2,180 m) . Between them the relatively plain areas of Kastoria , Florina , Ptolemais and Grevena are situated. In contrast, the eastern part of WD09 is dominated by the plains of Edessa, Naoussa, Veria and Pieria (Ειδική Γραμματεία Υδάτων, 2014c; 2014d).

WD09's population, based on 2001 census data of the Hellenic Statistical Authority was 601,726 inhabitants, while according to the 2011 census, there is a decrease of 3.5% (581,410 inhabitants).

The average annual rainfall ranges from 600 to 1.000 mm, while in the mountainous areas exceeds 1.200 mm. Snowfall is quite common during the period September - April. The mean annual temperature ranges between 14,5 and 17 ° C, with the coldest month in January and warmest in July.

According to a study by the Ministry of Development (ΥΠΑΝ, 2008), the average annual total water supply to the water district was estimated at 3.769 x 10^6 m^3, of which approximately 56,8 x 10^6 m^3 are transported underground from the WD09 to the WD10 through the karst system of Mountain Paiko.

6.5 Water Costs Analysis according to WFD

According to Article 5 of the WFD (2000):

"As part of the analysis of the River Basin characteristics, an economic analysis of Water uses must be conducted. According to specifications in Annex III, the economic analysis shall contain enough information in sufficient detail to

• Make the relevant calculations necessary for taking into account cost recovery of water services, taking account

of long term forecasts of supply and demand for water in the RBD and, where necessary: a) Estimates of the volume, prices and costs associated with water services:

b) Estimates of relevant investment including forecasts of such investments.

• Make judgements about the most cost effective combination of measures in respect of water uses to be included in the programme of measures under Article 11 based on estimates of the potential costs of such measures".

Based on that obligation three distinct cost categories are identified (Ειδική Γραμματεία Υδάτων, 2014a ;2014β):

- **Financial Cost:** is primarily allocated to management, operating and maintenance costs, in other words the cost of ensuring the proper functioning of the water service. Additionally, the cost of new infrastructure, the depreciation of existing infrastructure and new investments, i.e. capital cost, is included. In general, the cost subcategories are the following
    - **Capital Cost** - Annual depreciation of fixed assets (annual economic depreciation) and recent investments Includes pipelines, buildings, dams, drilling, water and drainage networks, irrigation networks for Local Land Reclamation Organisations (Τοπικοί Οργανισμοί Εγγείων Βελτιώσεων-TOEB), biological tanks and other permanent installations.
    - **Operating Costs -** Annual cost of energy expenditure of personnel and administration, cost of water supply, cost of materials, contributions to insurance institutions, debit interest, etc.
    - **Maintenance Costs –** Annual cost incurred to ensure the proper operation of facilities and fixed assets as well as any costs of repairing faults.
- **Environmental Cost:** consists in the valuation in monetary units of the environmental impacts of water resources from socio-economic activities. Economic assessment of environmental impacts is an issue that does not have a direct and clear approach. Therefore, different assessment methodologies have been proposed with associated restrictions (Μπίθας, 2011). It should be noted that the adequacy of the economic assessment of environmental pressures is in question under certain circumstances (Bromley, 1997; Bithas 2011). However, economic valuation is extremely useful in the process of internalizing the external costs of socio-economic processes. In this context, the economic assessment of pressures on aquatic ecosystems and resources in this study is also addressed.
- **Resource Cost:** This refers to the foregone benefits of either inefficient use of water use or over-use - use at an optimum level. Consequently, resource cost would be equated with the foregone benefits of that water use that lacks water, which under efficient water distribution it would not be deprived of it. In some cases, this water use is the one that yields the highest socio-economic benefit. (GD ECO 2, 2004; WATECO, 2002). In the case of the WD10 and WD09 covered by this study, the actual resource cost relates to those cases where water use is at a higher level than the rate of natural renewal, with the result that stocks of future uses are devoid of use.

6.6 Water uses- Water Services Cost in the WD of Western and Central Macedonia

The following three ecosystem services will be estimated:

- Provisioning service (freshwater provision) for both WDs
- Provisioning service (provision for agricultural water) for both WDs
- Provisioning service (water for electricity use) only for WD09

Therefore, the water services that correspond to those ecosystem services and consequently their providers should be identified.

The first provisioning service (freshwater provision) is identical with the Water Supply / Sewerage Service is provided by the Municipal Water Supply and Sewerage Company (Δημοτική Επιχείρηση Υδρεύσεως και Αποχέτευσης- ΔΕΥΑ/DEYA) as well as by the Municipalities, where there is no corresponding Water company.

The second provisioning service (provision for agricultural water) is identical with the Irrigation Service is mainly provided by the Local Land Reclamation Organizations (TOEBs), which extend to the boundaries of one or more Municipalities and for WD10 the General Land Improvement Organizations (Γενικός Οργανισμός Εγγείων Βελτιώσεων -ΓΟΕΒ) with a supervisory role mainly in the operation of certain TOEBs.

The third provisioning service (water for electricity use) will be based on the estimation of total water use cost for energy generated by Public Power Corporation S.A. for that calculation electricity generation by hydroelectric plants will be taken into consideration (Ειδική Γραμματεία Υδάτων, 2014a ;2014b).

6.7 Estimation of Financial Cost in the WD of Western and Central Macedonia- Methodology for Provisioning service (freshwater provision)

A number of primary and secondary sources were utilised for the calculation of the financial cost for both WDs. Firstly, a questionnaire was drafted, which was sent to the relevant water providers (DEYA and Municipalities). In particular, the data related to available investment expenditure, annual operating costs (Energy cost, personnel and administration expenses, fees to third parties, water supply, maintenance, materials and others) for the period 2010-2013, as well as recent capital investment over the last 20 years (Ειδική Γραμματεία Υδάτων, 2014a ;2014β)..

The final response by the competent bodies was limited and many of the data contained imperfections and so other data sources were used. Mainly for DEYA most information was derived from the balance sheets, income statements, operating accounts and assets when available. In some cases, the questionnaire of the Economic Committee of Municipal Union of Municipal Water Sewerage Companies (EDEYA) was also used for the last available year (2009) with a revaluation of their data at 2011 prices (Ειδική Γραμματεία Υδάτων, 2014a; 2014b).

Capital cost was calculated on the basis of the annual depreciation of depreciated fixed assets of DEYA / Municipality. It should be noted that economic rather than accounting depreciation is employed. This is due to the fact that economic depreciation is related to the useful life of the projects while accounting depreciations do not follow the rule of the useful economic life of the projects. For the calculation of the annual economic depreciations, "effective years of depreciation", the years on average in which it is estimated that the accumulated depreciation of DEYAs has been formed - the ratio of cumulative depreciation to annual depreciation (depreciation included in operating costs). Acquisition values were then converted into current prices based on the Consumer Price Index by the Bank of Greece and accordingly the project was amortized using specific depreciation rates (Ειδική Γραμματεία Υδάτων, 2014a; 2014b).

In particular, the depreciation rates for each project category are as follows (Ειδική Γραμματεία Υδάτων, 2012):

• Dams: depreciation factor of 1% (time horizon of 100 years)

• Pipelines, technical works and buildings: depreciation factor of 2% (time horizon of 50 years)

• Electromechanical equipment: depreciation factor 5% (time horizon 20 years)

For the remaining fixed assets of the Water Supply and Sewerage Services, the fixed depreciation method of the acquisition value was adopted based on the combinations of depreciation rates as described in Ministerial Decree No. 299/2003 (Government Gazette A 255).

The maintenance and operating costs were calculated both on the basis of the general holding accounts, when they were available. It is important to note that the depreciation included in the operating cost was deducted from the calculation method as these have already been calculated using the method described above. Also, for the older data, prices were updated at 2011 prices.

In the absence of data, deductions were made on the basis of average cost indicators calculated per inhabitant and m^3 in both WDs.

The collection of primary data and sometimes of secondary was confronted with a serious difficulty and created problems in the estimation of the financial cost. On the one hand, the implementation of the Administrative Reform Program "Kallikratis" in 2010 widened the competence area of most Municipalities in both WDs. Consequently, one crucial problem that emerged was that the Municipal Water Supply and Sewerage Companies (DEYAs) could not properly calculate its operational results. On the other hand, pre-existing administrative structures in advance could not correctly capture the operating costs of the Water-Sewerage Services. Thus, temporary difficulties arose due to this transitional period (Ειδική Γραμματεία Υδάτων, 2014a; 2014b).

A basic source of information for assessing the financial Cost of Water Supply and Sewerage Services in the Municipalities with no DEYA was the questionnaires and the personal communication that existed with the Municipalities. In many cases the Municipalities were quite cooperative given the situation. Nevertheless, in those Municipalities that were unable to find evidence, a method similar to that applied to DEYA was followed.

In these Municipalities, for which detailed operational expenditure figures were not found, they were calculated proportionally, based on the collected data from a representative sample of DEYAs and the municipalities for which data were available. With this method, the cost of operation per consumption m^3 of water was calculated and multiplied by the total consumption in the Municipality (Ειδική Γραμματεία Υδάτων, 2014a; 2014b).

6.7.1 Estimation of Financial Cost in the WD of Central Macedonia- Results

Provisioning service (freshwater provision)

The aggregate results for all DEYAs in the WD10 are presented in Table 6-4.

Table 6-4: Total financial cost, (cost categories) for each DEYA of WD10 for the year 2011. Source: Ειδική Γραμματεία Υδάτων, 2014a.

DEYA	Regional Unit	River Basin (RB)	Deprecia tion (€)	Operating Cost (€)	Maintenance Cost (€)	Total (€)
EYATH Thessaloniki Water Supply & Sewerage Utility	Thessalo niki	Chalkidiki	6,867,23 9	38,899,098	10,413,547	56,179,884
Volvi	Thessalo niki	Chalkidiki	889,000	1,784,500	320,000	2,993,500
Delta	Thessalo niki	Axios/ Gallikos	203,981	890,435 €	190,276	1,284,692
Thermaikos	Thessalo niki	Chalkidiki	905,974	1,351,298	702,382	2,959,654
Thermi	Thessalo niki	Chalkidiki	588,142	1,678,535	89,562	2,356,239
Lagada	Thessalo niki	Chalkidiki	161,146	2,865,851	119,604	3,146,602
Nea Propontida	Thessalo niki	Chalkidiki	784,595	2,950,148	174,766	3,909,509
Pylaia-Chortiatis	Thessalo niki	Chalkidiki	145,721	1,541,905	236,260	1,923,887
Chalkidonas	Thessalo niki	Gallikos/ Axios	309,635	1,351,647	288,832	1,950,114
Oraiokastro	Thessalo niki	Gallikos/ Chalkidiki	252,541	538,723	330,820	1,122,084
Kilkis	Kilkis	Axios/ Gallikos	1,403,53 0	5,270,370	263,703	6,937,603
Paionias	Kilkis	Axios	264,995	1,156,778	247,190	1,668,964

Alexandria	Imathia	Axios	676,982	1,077,852	79,667	1,834,501
Veroia	Imathia	Aliakmonas	1,353,279	4,242,651	857,449	6,453,380
Naoysa	Pella	Aliakmonas/ Axios	455,044	1,108,490	115,098	1,678,632
Almopia	Pella	Aliakmonas/ Axios	197,215	849,257	110,032	1,156,504
Pella	Pella	Axios	678,941	2,116,724	195,610	2,991,275
Skydra	Pella	Axios	106,561	1,237,700	418,286	1,762,547

Based on Figure 6-2, it appears that operating expenses in DEYA account for the largest proportion of total financial costs. On average, operating costs account for 69% of all financial Cost, and if maintenance costs together with operating costs are combined, this percentage increases to an average of 80% of the total financial cost (Ειδική Γραμματεία Υδάτων, 2014a).

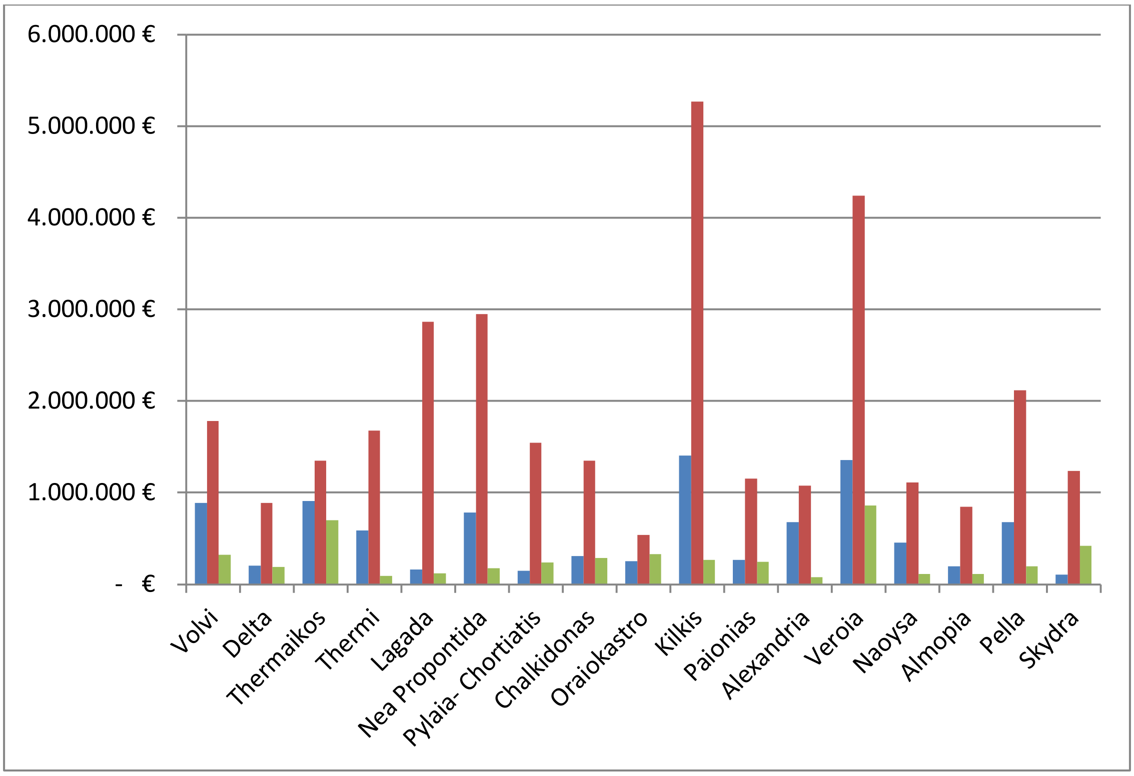


Figure 6-2 Total financial cost, (cost categories) for each DEYA (EYATH not included) of WD10 for the year 2011. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Based on Figure 6-3, which shows the cost of depreciation by DEYA, it can be assumed that high depreciation costs are apparent in DEYAs that provide water to large population, such as Veria and EYATH, while, with lower depreciation costs, the DEYA Thermaikos and Nea

Propontida, which has a correspondingly smaller population (Ειδική Γραμματεία Υδάτων, 2014a).

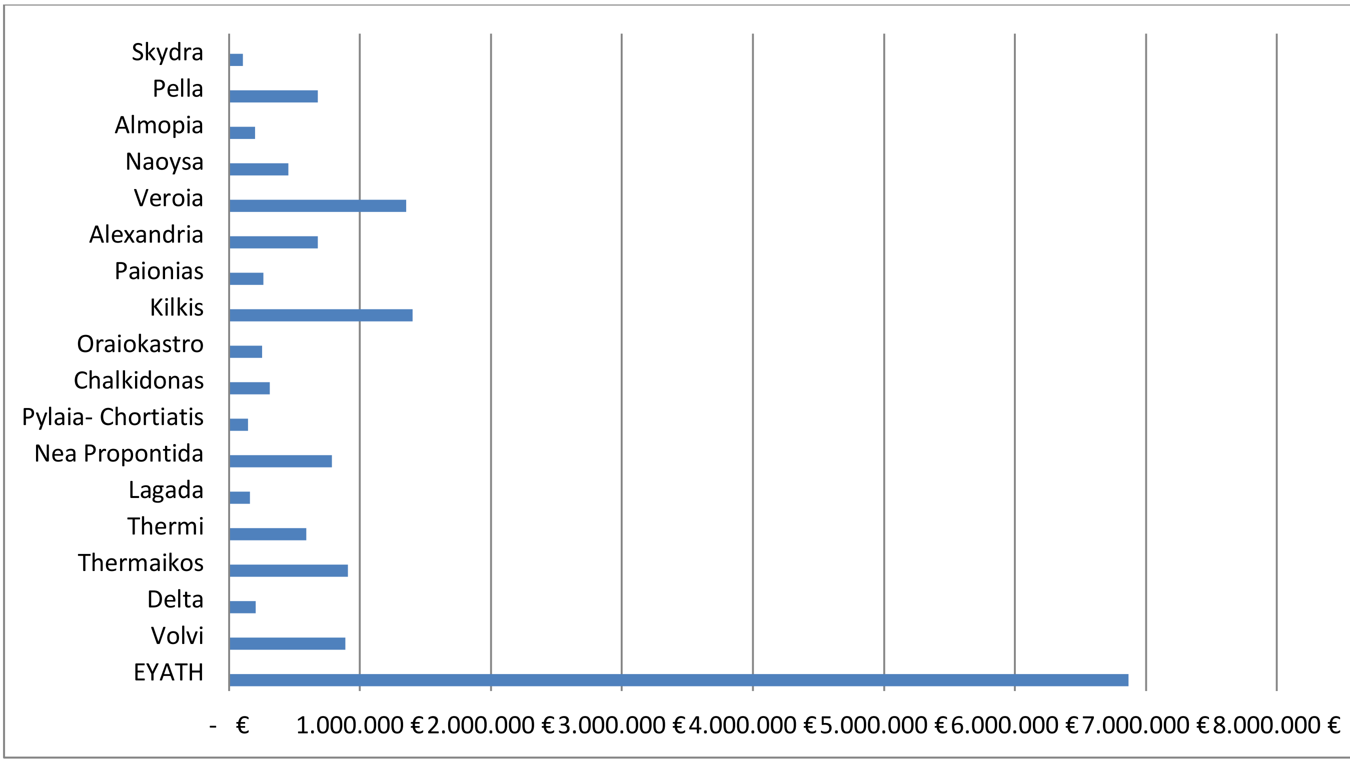


Figure 6-3 Total Depreciation Cost of DEYAs in WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

The next step is the estimation of financial cost per inhabitant and per unit volume of water (m^3). Absolute financial costs between DEYAs are surely not comparable, since it is evident that DEYAs serving more people have correspondingly increased financial costs. Therefore, the quote of financial cost per inhabitant and especially per m^3 is the most appropriate approach so that the individual data of DEYA can be compared (Ειδική Γραμματεία Υδάτων, 2014a).

According to Figure 6-4 variation between DEYAs in WD10 can be observed since the financial cost may range from € 39.4 to € 127 per inhabitant. The low cost per capita in DEYA is evident of Pilea-Hortiatis and in two of the DEYAs of the Regional Unit of Pella, while DEYA of the regional Unit of Kilkis, along with Veria, Nea Propontida and Volvi, have a high financial cost per person. It should be noted that population was derived from population census 2011 (Ειδική Γραμματεία Υδάτων, 2014a).

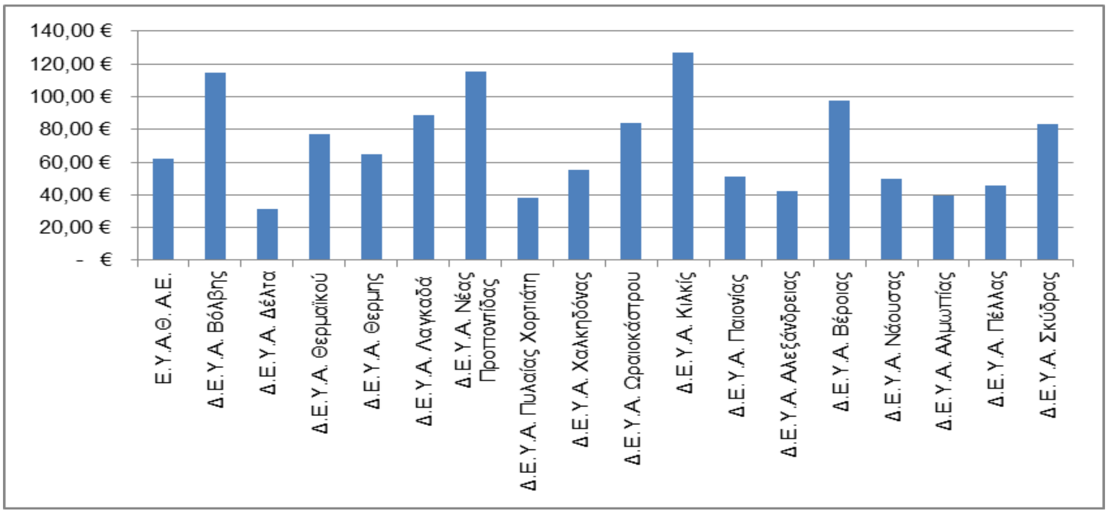


Figure 6-4 Financial cost per inhabitant for DEYAs in WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

However, if the cost per m^3 is estimated respectively, different conclusions can be drawn. In contrast with the financial cost per inhabitant, DEYA Skydras (1, 79 € / m^3) and Lagada (1, 92 € / m^3) have a relatively financial cost per unit. Particularly, the case of DEYA Volvis, which has a large financial cost per capita, but the corresponding unitary financial cost is relatively low (0.73 € / m^3), while the unit cost in DEYA is very high Pilaia-Hortiatis, something that is directly related to the leakages (Ειδική Γραμματεία Υδάτων, 2014a).

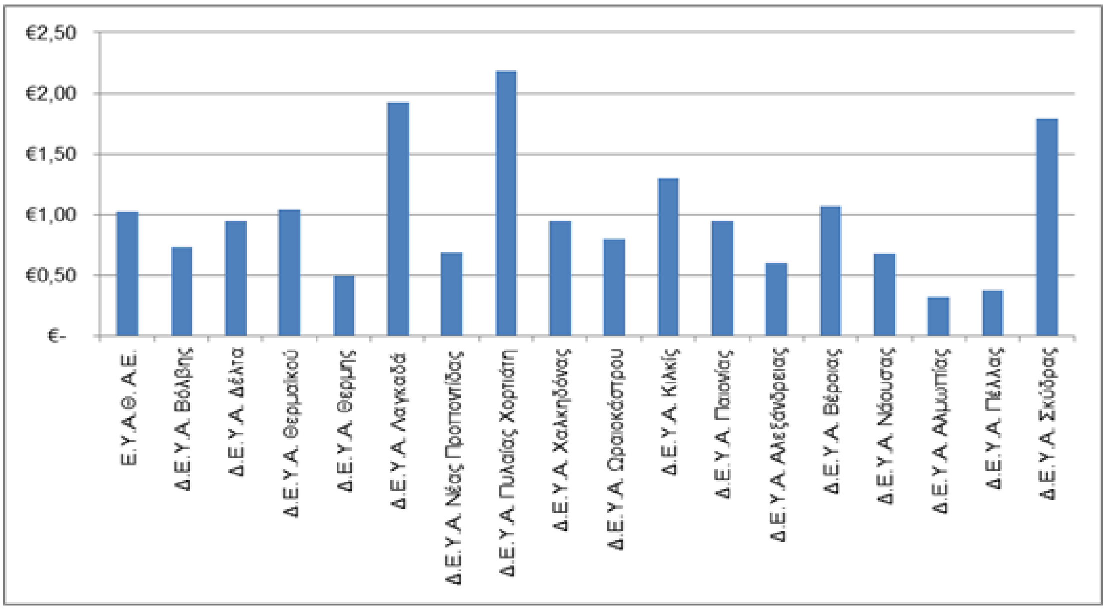


Figure 6-5 Financial cost per m^3 in the DEYAs of WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Applying the cost recovery principle as well as the polluter pays principle, i.e. that the user of an environmental service pays, would lead to the pricing of water uses depending on what quantities they actually use. The existence of significant leakages involves the charging of uses at a cost that have no relation to the actual use. The leakages are allocated proportionally and charged to the identified users respectively. In order to indicate the disproportionate burden on identified users this section estimates the unit cost of actual use (no leakages) compared to unit costs including leakages. The estimate should be interpreted as indicative as a leakage rate is considered to be related to the use of water. This, however, cannot justify the excessive leakage rates detected in several cases (Ειδική Γραμματεία Υδάτων, 2014a).

Total water consumption (without leakages) as well as total production and the respective unit cost per m^3 is presented in Table 6-5.

Table 6-5: Total Consumption, Production and respective unit cost in DEYAs of WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

DEYA	Total Consumption (m^3)	Total Production (m^3)	Leakage (%)	Unit cost (consumption- €/m^3)	Unit Cost (production- €/m^3)
Volvi	4,082,831	5,535,029	36	0.73 €	0.54 €
Delta	1,360,748	1,814,331	33	0.94 €	0.71 €
Thermaikos	2,834,554	3,769,957	33	1.04 €	0.79 €
Thermi	4,761,060	6,548,000	37	0.36 €	0.14 €
Lagada	1,638,314	2,457,471	50	1.92 €	1.28 €
Nea Propontida	5,680,000	9,088,000	60	0.69 €	0.43 €
Pylaia-Chortiatis	882,955	2,370,240	168	2.18 €	0.71 €
Chalkidonas	2,065,564	3,066,000	48	0.94 €	0.64 €
Oraiokastro	1,400,000	1,946,000	39	0.80 €	0.58 €
Kilkis	5,338,201	7,117,601	33	1.30 €	0.97 €
Paionias	1,767,769	2,357,026	33	0.94 €	0.71 €
Alexandria	3,067,117	4,599,650	50	0.60 €	0.40 €
Veroia	6,025,142	7,552,000	25	1.07 €	0.85 €
Naoysa	2,464,500	3,286,000	33	0.68 €	0.51 €
Almopia	3,553,400	5,448,363	53	0.33 €	0.21 €
Pella	7,914,200	9,497,040	20	0.38 €	0.31 €
Skydra	982,602	1,154,957	18	1.79 €	1.53 €

Based on Table 6-5, the reduction in unit cost per m^3, may reach up to 1.37 € / m^3 in the case of DEYA Pilaias-Chortiatis. It is evident that DEYA Pylaia-Hortiatis has a very unit cost in consumption due to both network failures and illegal water abstractions that cannot be easily identified. Accordingly, the second largest decrease in unit cost between production and consumption occurs in DEYA Lagada (0.64 € / m3). A relatively small reduction in unit costs is reported in the DEYA Pella, with a decrease of 0.06 € / m^3. On average, this decrease is estimated at the DEYAs of WD10 at € 0.33 / m^3.However, it should be noted that the above estimates are indicative of the cost of leakage and in no case can they be fully interpreted, as it is certain that the leaks will continue to exist. However, they must not exceed a reasonable percentage of consumption (Ειδική Γραμματεία Υδάτων, 2014a).

Due to the importance of Thessaloniki Water Supply & Sewerage Utility (EYATH- Υπηρεσία Ύδρευσης Αποχέτευσης Θεσσαλονίκης- EYATH), as it provides water to the second largest city of Greece, the respective results are presented in Table 6-6.

Table 6-6: Total consumption, production and respective unit cost in EYATH. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Total Consumption (m^3)	Leakage (m^3)	Total Production (m^3)	Leakage (%)	Unit cost (consumption- €/m3)	Unit Cost (production- €/m3)
54,927,462	26,464,954	81,392,416	32%	1.02 €	0.69 €

In addition, there are 4 Municipalities that do not have an active DEYA and are located in the Regional Unit in Chalkidiki. Furthermore, the Mount Athos, the autonomous polity within the Hellenic Republic is also taken into consideration.

Table 6-7: Total financial cost, (cost categories) for each Municipality of WD10 for the year 2011. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Municipalities	Depreciation (€)	Operating Cost (€)	Maintenance Cost (€)	Total (€)
Aristotelis	1,258,807	1,852,053	648,615	3,759,475
Kassandra	1,018,900	1,499,083	525,000	3,042,983
Sithonia	775,670	3,686,388	768,612	5,230,671
Polygyros	422,333	621,368	217,612	1,261,313
Athos	26,002	38,256	13,398	77,656

As with the DEAYS, the next step is the estimation of financial cost per inhabitant and per unit volume of water (m^3).

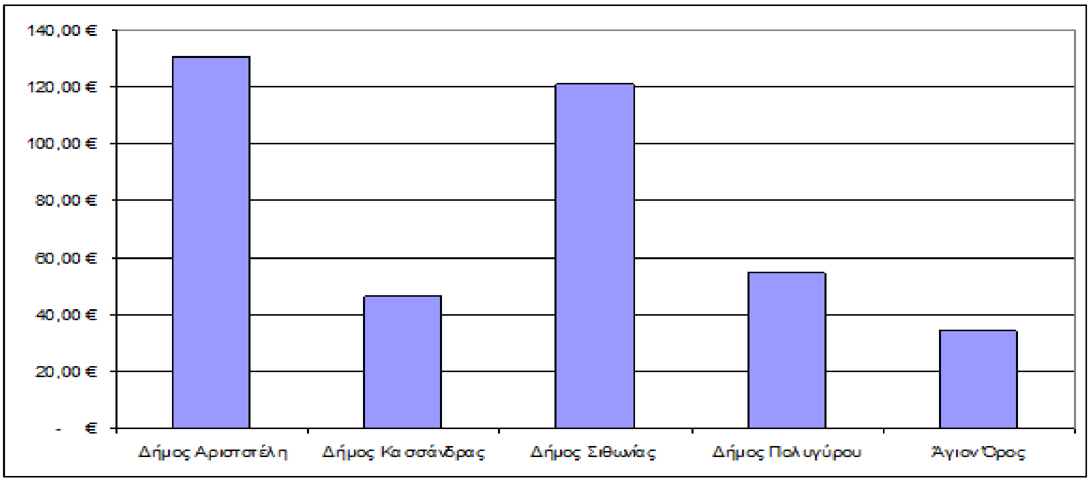


Figure 6-6 Financial cost per inhabitant for Municipalities in WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

It should be noted that for the calculation of per capita financial cost the equivalent population was taken into (seasonal population growth). This is due to the fact that basically, the Municipalities of Kassandra and Sithonia, reach high number of visitors during the summer months (Ειδική Γραμματεία Υδάτων, 2014a).

Additionally, the total production and consumption as well as their respective cost are presented in Table 6-8.

Table 6-8: Unit Cost (consumption and production) for Municipalities in WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Municipalities	Unit cost (production-€/m3)	Unit Cost (consumption- €/m^3)	Leakage (%)
Aristotelis	0.87 €	0.67 €	30%
Kassandra	0.65 €	0.56 €	18%
Sithonia	0.99 €	0.75 €	33%
Polygyros	0.89 €	0.67 €	33%
Athos	0.62 €	0.49 €	25%

Finally, the total financial cost, distributed in each respective River Basin of WD10, along with unit costs is presented in Table 6-9 (Ειδική Γραμματεία Υδάτων, 2014a).

Table 6-9: Total Financial Cost, Average Unit Cost (Production and Consumption) in River Basins of WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

WD10 River Basins	Total Financial Cost (€)	Average Cost per m^3 (consumption-€/m^3)	Average Cost per m^3 (production-€/m^3)
Axios (GR03)	19,611,330 €	0.80 €	0.75 €
Gallikos (GR04)	8,055,555 €	1.04 €	0.71 €
Chalkidiki (GR05)	79,190,082 €	0.96 €	0.66 €
Athos (GR43)	885,704 €	0.87 €	0.66 €

6.7.2 Estimation of Financial Cost in the WD of Western Macedonia- Results Provisioning service (freshwater provision)

A similar approach is followed for WD09. The aggregate results for all DEYAs in the WD10 are presented in Table 6-10.

Table 6-10: Total financial cost, (cost categories) for each DEYA of WD09 for the year 2011. Source: Ειδική Γραμματεία Υδάτων, 2014b.

DEYA	Regional Unit	River Basin (RB)	Depreciation (€)	Operating Cost (€)	Maintenance Cost (€)	Total (€)
Alexandria	Imathia	Aliakmonas/ Axios	676,982	1,077,851	79,667	1,834,501
Veroia	Imathia	Aliakmonas/ Axios	1,353,279	4,242,651	857,449	6,453,380
Naousa	Imathia	Aliakmonas/ Axios	455,044	1,108,489	115,098	1,678,632
Kastoria	Kastoria	Aliakmonas	1,616,164	2,193,981	117,682	3,927,827
Kozani	Kozani	Aliakmonas	2,347,961	7,906,004	1,013,171	11,267,136
Eordaia	Kozani	Aliakmonas	670,926	7,537,331	23,008	8,231,267
Edessa	Pella	Aliakmonas/ Axios	320,435	751,969	176,245	1,248,650
Almopia	Pella	Aliakmonas/ Axios	197,215	849,256	110,032	1,156,504
Pella	Pella	Aliakmonas/ Axios	678,941	2,116,724	195,610	2,991,275
Skydra	Pella	Aliakmonas/ Axios	106,561	1,237,700	418,286	1,762,547
Katerini	Pieria	Aliakmonas	2,036,970	5,492,516	481,724	8,011,212
Dion-Anatolikos Olympos	Pieria	Aliakmonas	672,075	1,652,639	318,495	2,643,210
Florina	Florina	Aliakmonas/ Prespes	73,182	1,435,066	997,982	2,506,230

Based on Table 6-8, it appears that operating expenses in DEYA account for the largest proportion of total financial costs. On average, operating costs account for 67% of all financial Cost, and if maintenance costs together with operating costs are combined, this percentage increases to an average of 75% of the total financial cost (Ειδική Γραμματεία Υδάτων, 2014b).

Based on Figure 4-6, which shows the cost of depreciation by DEYA, it can be assumed that high depreciation costs are apparent in DEYAs that provide water to large population, such as Katerini and Kozani, while, with lower depreciation costs, the DEYA Kastoria, which has a correspondingly smaller population (Ειδική Γραμματεία Υδάτων, 2014b).

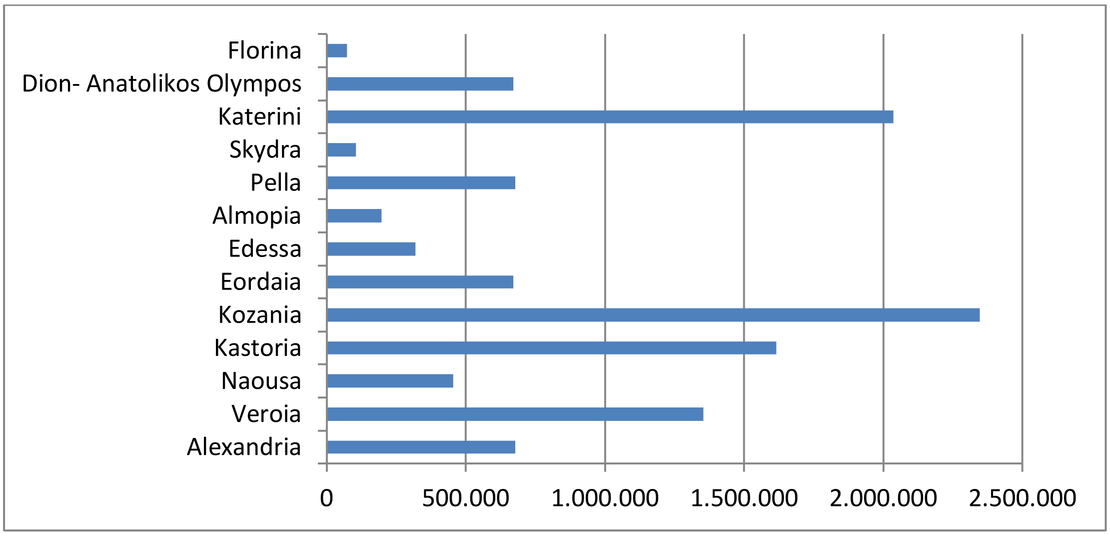


Figure 6-7 Total Depreciation Cost of DEYAs in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

The next step is the estimation of financial cost per inhabitant and per unit volume of water (m^3).

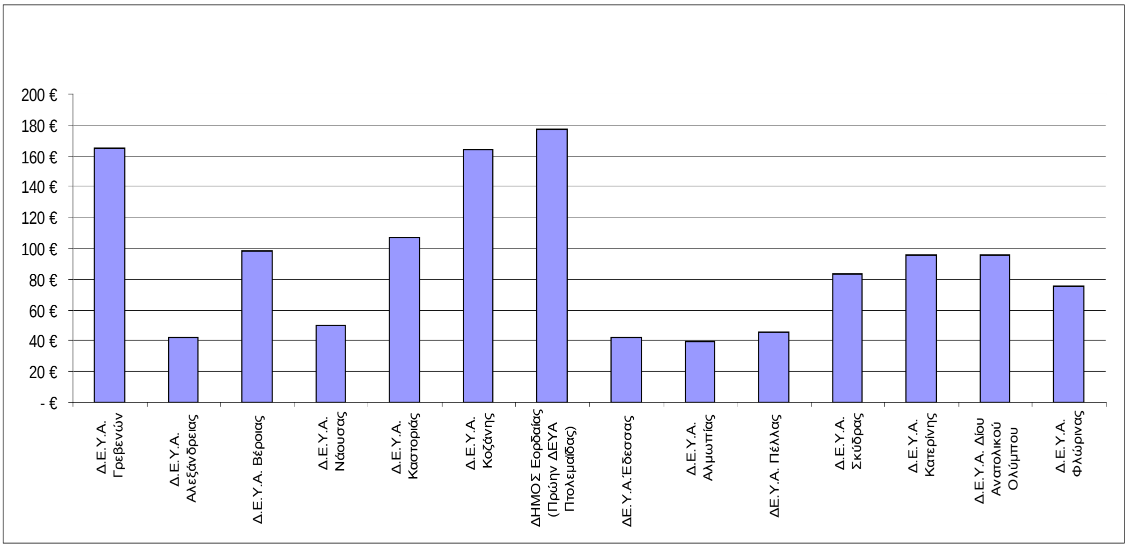


Figure 6-8 :Financial cost per inhabitant for DEYAs in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

According to Figure 6-8 , variation between DEYAs in WD09 can be observed since the financial cost may range from € 39.4 to € 176.86 per inhabitant. The low cost per capita in DEYA is evident in Almopia, while DEYA of the regional Unit of Kozani, along with Grevena have a high financial cost per person. It should be noted that population was derived from population census 2011 (Ειδική Γραμματεία Υδάτων, 2014b).

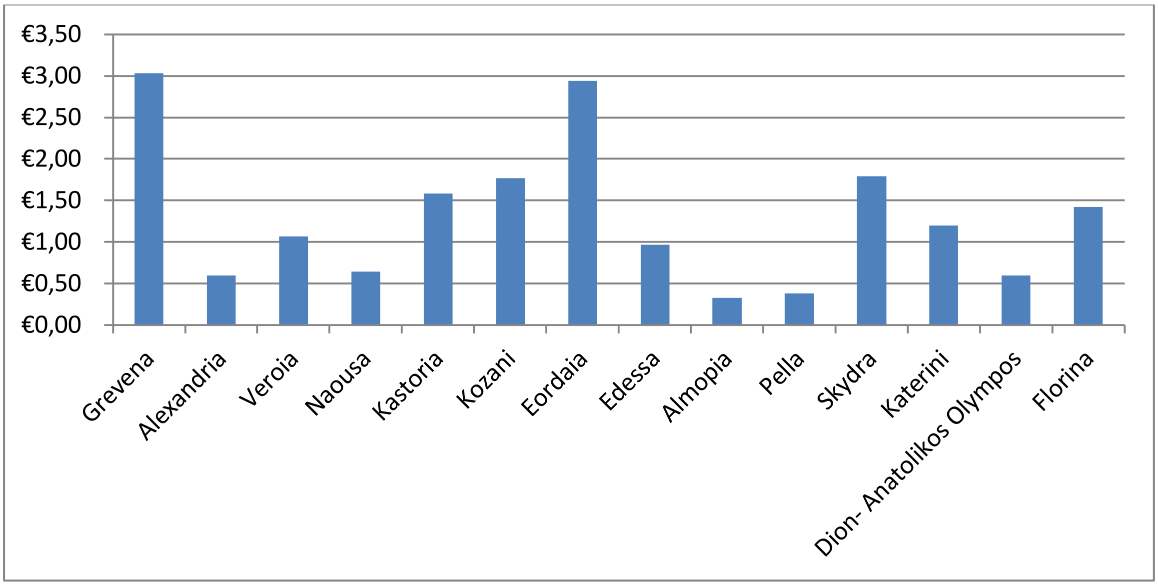


Figure 6-9: Financial cost per m³ in the DEYAs of WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

However, if the cost per m³ is estimated respectively, different conclusions can be drawn. DEYA Veria exhibits a low unit cost and while DEYA Kozani and Kastoria exhibit similar unitary financial unit cost, despite the fact that the financial Cost per inhabitant in Kozani is higher than that of Kastoria. It should be noted that is a relatively low unit cost is found in Katerini, which is due to the high water consumption. On the other hand, the unit cost in Skydra is relatively high. Finally, a lower unit cost is presented in Pella and Almopia Ειδική Γραμματεία Υδάτων, 2014b).

Total water consumption (without leakages) as well as total production and the respective unit cost per m³ is presented in Table 6-11.

Table 6-11: Total Consumption, Production and respective unit cost in DEYAs of WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

DEYA	Total Consumption (m³)	Total Production (m³)	Leakage (%)	Unit cost (consumption - €/m³)	Unit Cost (production- €/m³)
Grevena	1,626,750	2,169,000	33%	3.03 €	2.27 €
Alexandria	3,067,117	4,599,650	50%	0.60 €	0.40 €
Veroia	6,025,142	7,552,000	25%	1.07 €	0.85 €
Naousa	2,628,800	3,286,000	25%	0.64 €	0.51 €
Kastoria	2,480,004	3,306,703	33%	1.58 €	1.19 €
Kozani	6,360,255	8,480,340	33%	1.77 €	1.33 €
Eordaia	2,795,250	3,727,000	33%	2.94 €	2.21 €
Edessa	1,286,791	2,089,908	62%	0.97 €	0.60 €
Almopia	3,553,400	5,448,363	53%	0.33 €	0.21 €

Pella	7,914,200	9,497,040	20%	0.38 €	0.31 €
Skydra	982,602	1,154,957	18%	1.79 €	1.53 €
Katerini	6,700,000	11,043,580	65%	1.20 €	0.73 €
Dion-Anatolikos Olympos	4,371,833	5,829,111	33%	0.60 €	0.45 €
Florina	1,667,786	2,200,000	25%	1.42 €	1.14 €

Based on Table 6-11, the reduction in unit cost per m^3, may reach up to 0.75€ / m^3 in the case of DEYA Grevena and 0.73€ / m^3 in DEYA Eordaia. A relatively small reduction in unit costs is reported in the DEYA Pella, with a decrease of 0.06 € / m^3. On average, this decrease is estimated at the DEYAs of WD09 at € 0.32 / m^3.However, it should be noted that the above estimates are indicative of the cost of leakage and in no case can they be fully interpreted, as it is certain that the leaks will continue to exist. However, they must not exceed a reasonable percentage of consumption (Ειδική Γραμματεία Υδάτων, 2014b).

In addition, there are 9 Municipalities that do not have an active DEYA and are located in the almost all Regional Units of WD09.

Table 6-12: Total financial cost, (cost categories) for each Municipality of WD09 for the year 2011. Source: Ειδική Γραμματεία Υδάτων, 2014b.

Municipalities	Regional Unit	Depreciation (€)	Operating Cost (€)	Maintenance Cost (€)	Total (€)
Deskati	Grevena	134,955 €	251,848 €	114,252 €	501,056 €
Nestorio	Kastoria	77,151 €	71,802 €	38,738 €	187,692 €
Orestidos	Kastoria	216,034 €	417,089 €	108,471 €	741,594 €
Voion	Kozani	275,024 €	513,240 €	232,832 €	1,021,097 €
Servia-Velvento	Kozani	383,550 €	715,768 €	324,710 €	1,424,028 €
Pydna-Kolindros	Pieria	348,124 €	649,656 €	294,718 €	1,292,499 €
Amyntaio	Florina	540,234 €	428,100 €	108,000 €	1,076,334 €
Prespes	Florina	71,490 €	56,651 €	14,291 €	142,433 €
Metsovo	Ioanninon	43,072 €	80,380 €	36,465 €	159,918 €

As with the DEYAs, the next step is the estimation of financial cost per inhabitant and per unit volume of water (m^3).

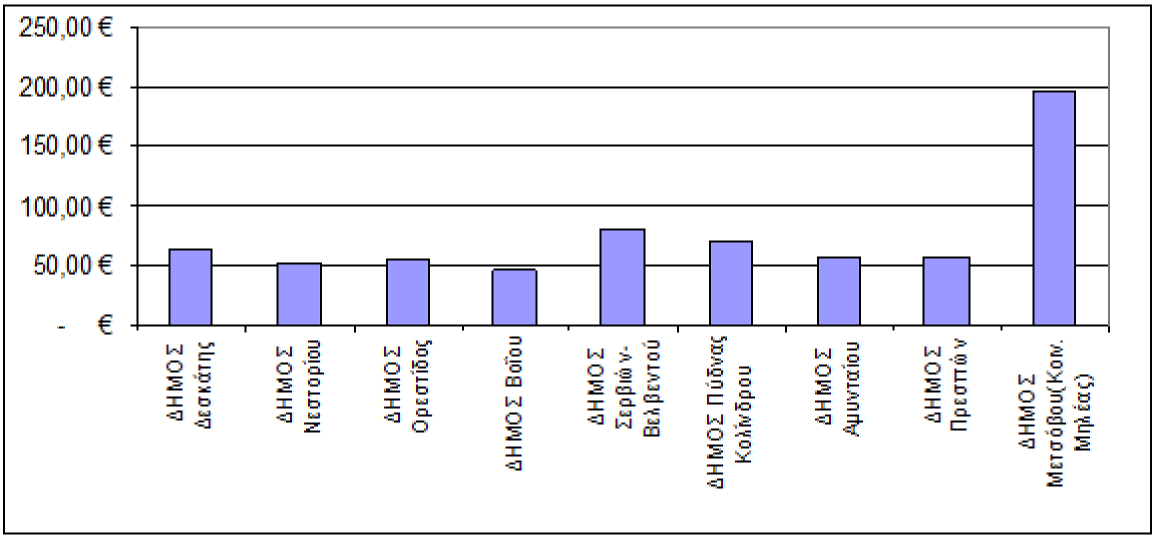


Figure 6-10: Financial cost per inhabitant for Municipalities in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

Additionally, the total production and consumption as well as their respective cost are presented in Table 6-13.

Table 6-13: Unit Cost (consumption and production) for Municipalities in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

Municipalities	Total Consumption (m^3)	Total Production (m^3)	Leakage (%)	Unit cost (consumption- €/m^3)	Unit Cost (production- €/m^3)
Deskati	494,713	644,529	30%	1.01 €	0.78 €
Nestorio	195,000	260,000	33%	0.96 €	0.72 €
Orestidos	1,433,962	1,911,949	33%	0.52 €	0.39 €
Voion	2,577,426	3,552,768	38%	1.08 €	0.81 €
Servia-Velvento	4,836,300	6,909,000	43%	1.09 €	0.82 €
Pydna-Kolindros	581,115	796,127	37%	1.35 €	0.88 €
Amyntaio	301,812	431,160	43%	0.22 €	0.16 €
Prespes	876,000	1,347,692	54%	0.49 €	0.36 €
Metsovo	1,965,631	2,598,853	30%	0.53 €	0.37 €

The lowest unit cost (around 0.22 € / m^3) appears in Amyntaio, while the highest one appears in Pydna-Kolindros. The low unit cost for Amyntaio is mainly due to the fact that, Amyntaio has the highest consumption in the WD09. Also interesting is the case of Metsovo, which, while exhibiting the highest financial cost per inhabitant, shows a relatively lower financial cost per m^3 (0.53 € / m^3) (Ειδική Γραμματεία Υδάτων, 2014b).

Finally, the total financial cost, distributed in each respective River Basin of WD09, along with unit costs is presented in Table 6-14 (Ειδική Γραμματεία Υδάτων, 2014b).

Table 6-14: total financial cost, distributed in each respective River Basin of WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

WD09 River Basins	Total Financial Cost (€)	Average Cost per m^3 (consumption-€/m^3)	Average Cost per m^3 (production- €/m^3)
Aliakmonas (GR02)	51,745,540 €	1.04 €	0.75 €
Prespes (GR01)	2,473,449 €	0.55 €	0.37 €
Total	54,218,989 €		

6.8 Estimation of Financial Cost in the WD of Western and Central Macedonia- Methodology for Provisioning service (provision of agricultural water)

The estimation of the financial cost of the provisioning service of agricultural water is identical to the calculation of the freshwater provisioning service. Consequently, three distinct cost categories are taken into consideration: Capital cost, Operational cost and Administrative and maintenance cost (Ειδική Γραμματεία Υδάτων, 2014a; 2014b).

It should be noted that only the financial cost of organized irrigation can be calculated, i.e. from Local and General Land Reclamation Organisations (GOEB and TOEB). Additionally, the percentage of organised irrigation is approximately 49% in WD10 and 40% in WD09. Only in the administrative unit of Imathia this percentage reaches 80% (ΙΝΑΣΟ, 2009).

The estimation of the financial cost of the irrigation service is based is as follows:

• Questionnaires to TOEB / GOEB and competent services of the regional units;

• Budget of irrigation projects included in National Reference Framework Programmes;

• Study of the Institute of Agricultural and Cooperative Economy (ΙΝΑΣΟ, 2009).

Given the difficulty of finding data on operating costs mainly on TOEBs, data from older years, they were adjusted to 2011 prices through the Consumer Price Index. The following method was used for TOEBs for which there was no data available: in each Regional Unit, the weighted average cost for each cost category per m^3 was calculated from the completed questionnaires and then this unit cost was used with the withdrawals of each TOEB in each cost category for those organisations without available data (Ειδική Γραμματεία Υδάτων, 2014a; 2014b).

In relation to capital cost, reliable data on fixed assets costs is not reflected in the financial statements as there are simply references to their annual expenses and revenues. Thus, the cost of fixed assets was calculated on the basis of similar projects for which data were available, as well as the INASO study (2009). The depreciation rates were then calculated based on a useful life of the fixed assets as 30 years. Thus, an annual depreciation cost of 7.89 € / acre was estimated when there was surface water abstraction and, respectively, when underground water abstraction, the corresponding cost was estimated at 34.1 € / acre (Ειδική Γραμματεία Υδάτων, 2014a; 2014b).

As far as operating and administration and maintenance costs are concerned, the annual costs of TOEBs in terms of administrative costs, running costs of projects and pumping stations (electricity costs) and the corresponding maintenance costs are included. It should also be noted that no account has been taken of past liabilities.

6.8.1 Estimation of Financial Cost in the WD of Central Macedonia- Results

Provisioning service (provision of agricultural water)

Table 6-15 presents a full overview of each cost category in each regional unit.

Table 6-15: Aggregate financial cost of organized irrigation in WD10. Source: (Ειδική Γραμματεία Υδάτων, 2014a)

Regional Unit Thessaloniki	Depreciation (€)	Operating Cost (€)	Maintenance Cost (€)	Total (€)	Irrigated Acres (m^2)	Withdrawals (m^3)	Cost/ acre	Cost/ m^3
Aghios Athanassios	385,792	320,903	301,249	1,007,944	48,890	88,231,680	20.62	0.011
Vrachias	398,221	314,737	201,600	914,558	50,465	40,180,320	18.12	0.023
Kymina/ Malgara	350,125	213,320	197,320	760,765	44,370	74,342,880	17.15	0.010
M. Monastiriou	478,196	428,806	327,216	1,234,219	60,600	65,901,600	20.37	0.019
Nea Magnisia	97,849	127,592	18,400	243,841	12,400	6,488,640	19.66	0.038
Chalastra/ Kalochori	495,683	358,077	299,148	1,152,908	62,816	119,949,120	18.35	0.010
Chalkidona	221,517	97,431	81,397	400,345	28,072	32,637,600	14.26	0.012
Koufalia	77,135	25,644	11,399	114,178	9,775	4,570,560	11.68	0.025
Askos	10,258	2,266	1,893	14,418	1,300	759,200	11.09	0.019
Mikri Volvi	22,095	4,881	4,078	31,054	2,800	1,635,200	11.09	0.019
Nymfopetra	47,346	8,455	7,764	63,565	6,000	2,832,400	10.59	0.022
Regional Unit Imathia	**Depreciation (€)**	**Operating Cost (€)**	**Maintenance Cost (€)**	**Total (€)**	**Irrigated Acres (m^2)**	**Withdrawals (m^3)**	**Cost/ acre**	**Cost/ m^3**
Alexandreia	181,060	300,265	227,377	708,702	22,945	15,590,880	30.89	0.045
Zervochori	132,885	218,184	75,457	426,526	16,840	13,011,840	25.33	0.033
Kleidi	138,835	339,247	20,018	498,100	17,594	25,436,160	28.31	0.020
Chamilia Schoina	193,267	329,005	78,001	600,273	24,492	17,301,600	24.51	0.035
Ipsili Schoina	94,653			94,653	11,995	8,501,760	7.89	0.011
Nisi A	85,965	310,769	55,694	452,428	10,894	7,823,520	41.53	0.058
Nisi B	75,991	-		75,991	9,630	6,018,624	7.89	0.013
Ksechasmeni	231,286	362,452	57,600	651,338	29,310	25,535,520	22.22	0.026
Prasinada	137,170	195,736	61,260	394,165	17,383	11,288,160	22.68	0.035
Skilitsi/ Kavasila	131,251	299,658	46,091	477,000	16,633	8,920,800	28.68	0.053
Bryaki/ Loutro	135,726	194,037	55,932	385,695	17,200	14,770,080	22.42	0.026

Niseliou/ Koryfi	155,548	186,347	81,063	422,958	19,712	12,773,376	21.46	0.033
Stavros	221,951	263,011	124,912	609,874	28,127	18,390,240	21.68	0.033
Trikala/ Plateos	437,620	437,067	212,872	1,087,560	55,458	35,428,320	19.61	0.031
Regional Unit Kilkis	**Depreciation (€)**	**Operating Cost (€)**	**Maintenance Cost (€)**	**Total (€)**	**Irrigated Acres (m^2)**	**Withdrawals (m^3)**	**Cost/ acre**	**Cost/ m^3**
Axioupoli	67,074	179,903	35,631	282,608	8,500	6,234,636	33.25	0.045
Goumenissa	49,000	23,356	4,626	76,982	1,400	809,424	54.99	0.095
Gorgopi	64,750	30,864	6,113	101,727	1,850	1,069,596	54.99	0.095
Aspros	83,561	67,566	13,382	164,509	4,050	2,341,547	40.62	0.070
Plagia	52,500	25,025	4,956	82,481	1,500	867,240	54.99	0.095
Pontoirakleia	13,415	28,361	5,617	47,393	1,700	982,872	27.88	0.048
K. Sourmena	6,707	14,181	2,809	23,697	850	491,436	27.88	0.048
Amaranta	499,100	48,381	9,582	557,063	2,900	1,676,664	192.09	0.332
Axiochori	80,500	38,371	7,600	126,471	2,300	1,329,768	54.99	0.095
Mikrodasos	14,204	30,030	5,948	50,181	1,800	1,040,688	27.88	0.048
Artzan/ Armatovo	456,702	441,435	87,429	985,566	28,000	15,298,120	35.20	0.064
Chamilo/ Eidomeni	3,788	10,159	2,012	15,959	480	352,073	33.25	0.045
Regional Unit Pella	**Depreciation (€)**	**Operating Cost (€)**	**Maintenance Cost (€)**	**Total (€)**	**Irrigated Acres (m^2)**	**Withdrawals (m^3)**	**Cost/ acre**	**Cost/ m3**
Arapitsa/ Pediada	181,415	549,016	69,045	799,476	22,990	17,926,584	34.77	0.045
Giannitsa	95,521	540,352	111,095	746,967	12,105	7,473,600	61.71	0.100
Giannitsa/ Tsekre	68,841			68,841	8,724	4,237,920	7.89	0.016
Krya Vrysi	204,922	364,244	72,141	641,307	25,969	12,623,040	24.70	0.051
Aravissos	243,872	559,455	110,804	914,131	30,905	19,388,160	29.58	0.047
Aghios Loukas/Karyotissa	203,880	438,040	86,757	728,678	25,837	15,180,480	28.20	0.048
Mpalitsa/ Karyotissa	185,518	357,263	70,758	613,540	23,510	12,381,120	26.10	0.050
Nichori	115,832	154,074	30,516	300,422	14,679	5,339,520	20.47	0.056

The highest unit cost (per acre and m^3) is estimated in the Regional Unit of Kilkis. This is mainly due to the fact that Kilkis is the sole regional unit, where there are groundwater withdrawals and consequently, the financial cost is considerably high (Ειδική Γραμματεία Υδάτων, 2014a).

Apart from the TOEBS in the WD10, there is also the General Reclamation Organisation of Thessaloniki- Lagadas (GOEB). GOEB is responsible for the construction and maintenance of irrigation infrastructure in TOEBs and in areas, where no TOEB is active (Ζορμπά, 2010). As

GOEB is active on a very large area of WD10 a separate estimation of the financial cost was carried out.

Table 6-16: Aggregate financial cost of GOEB Thessaloniki- Lagada. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Irrigated Acres m^2	Depreciation (€)	Operating Cost(€)	Maintenance Cost (€)	Total (€)
1,060,000	8,364,486	452,001	1,972,620	10,789,108

Finally, the total financial cost, distributed in each respective River Basin of WD10, along with unit costs is presented in Table 6-18 (Ειδική Γραμματεία Υδάτων, 2014a).

Table 6-17: Total financial cost and weighted average financial cost in WD10 for provisioning service (provision of agricultural water). Source: Ειδική Γραμματεία Υδάτων, 2014a.

RB	Total Financial Cost (€)	Weighted Average Financial Cost (€/m^3)
Axios (GR03)	28,788,494	0.05
Gallikos (GR04)	243,841	0.04
Chalkidiki (GR05)	109,038	0.02
Athos (GR43)	0	0

6.8.2 Estimation of Financial Cost in the WD of Western Macedonia- Results Provisioning service (provision of agricultural water)

Table 6-18 presents a full overview of each cost category in each regional unit.

Table 6-18: Aggregate financial cost of organized irrigation in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

Regional Unit Grevena	Depreciation (€)	Operating Cost (€)	Maintenance Cost (€)	Total (€)	Irrigated Acres (m^2)	Withdrawals (m^3)	Cost/ acre	Cost/ m^3
Vatolakkos	45,150	14,753	2,922	62,825	1,290	511,294	48.70	0.123
Poros	14,000	4,574	906	19,480	400	158,541	48.70	0.123
Paliouras	13,414	19,442	3,850	36,708	1,700	673,798	21.59	0.054
Taxiarchis	7,891	11,436	2,265	21,593	1000	396,352	21.59	0.054
Karpero-Dimitra	95,281	137,243	27,181	259,706	12,000	4,756,224	21.64	0.055
Kivotos-Kokkinia-Polydendri	30,775	44,604	8,834	84,213	3900	1,545,773	21.59	0.054
Paliochori	789	1,143	226	2,159	100	39,635	21.59	0.054

Paraskeyi-Deskati	3,945	5,718	1,132	10,796	500	198,176	21.59	0.054
Ag. Georgios-Deskati	4,734	6,862	1,359	12,955	600	237,811	21.59	0.054
Kyrakali	3,550	5,146	1,019	9,716	450	178,358	21.59	0.054
Agapi	7,101	10,293	2,038	19,433	900	356,717	21.59	0.054
Pigaditsa	4,734	6,862	1,359	12,955	600	237,811	21.59	0.054
Exarchos	9,469	13,724	2,718	25,911	1,200	475,622	21.59	0.054
Mayranaioi	1,972	2,859	566	5,398	250	99,088	21.59	0.054
Paliochori	2,367	3,431	679	6,477	300	118,906	21.59	0.054
Kentro	2,761	4,002	792	7,557	350	138,723	21.59	0.054
Regional Unit Kastoria	**Depreciation (€)**	**Operating Cost (€)**	**Maintenance Cost (€)**	**Total (€)**	**Irrigated Acres (m^2)**	**Withdrawals (m^3)**	**Cost/ acre**	**Cost/ m^3**
Koresteia A	48,744	43,283	30,634	122,661	3,042	1,500,000	40.32	0.082
Koresteia B	17,060	43,283	30,634	90,977	2,162	1,500,000	42.08	0.061
Koresteia-Makrochori	1,104	1,921	1,360	4,386	140	66,598	31.33	0.066
Vasileiada-Verga	6,656	6,863	4,857	18,377	500	237,850	36.75	0.077
Vasileiada-Verga	33,600	32,943	23,316	89,860	2,400	1,141,680	37.44	0.079
Vasileiada-Melissotopos	18,359	13,452	9,520	41,332	980	466,186	42.18	0.089
Vasilieada-Aspropotamos	36,155	14,179	10,035	60,370	1,033	491,398	58.44	0.123
Lithia	112,000	43,924	31,088	187,013	3,200	1,522,240	58.44	0.123
Kolokynthous-Koromilias	39,652	28,855	20,422	88,930	5,025	1,000,000	17.70	0.089
Kolokynthous-Lrykis	16,137	28,070	19,867	64,075	2,045	972,807	31.33	0.066
Nestorio	7,654	13,314	9,423	30,392	970	461,429	31.33	0.066
Aliakmona	2,367	4,117	2,914	9,399	300	142,710	31.33	0.066
Aliakmona-Kalochori	17,360	30,198	21,373	68,931	2,200	1,046,540	31.33	0.066

Aliakmona-Pentavrysou	5,523	9,608.00	6,800	21,932	700	332,990	31.33	0.066
Aliakmona-Chiliodendriou	16,965	29,512.00	20,887	67,365	2,150	1,022,755	31.33	0.066
Vyssinia	5,523	8,079	5,718	19,321	700	280,000	27.60	0.069
Vrachos	51,291	54,825	38,803	144,920	6,500	1,900,000	22.30	0.076
Ieropigi A	4,174	7,261	5,139	16,575	529	251,645	31.33	0.066
Ieropigi B	1,893	3,294.00	2,331	7,519	240	114,168	31.33	0.066
Dialekto	3,803	6,616	4,682	15,102	482	229,287	31.33	0.066
Regional Unit Florina	**Depreciation (€)**	**Operating Cost (€)**	**Maintenance Cost (€)**	**Total (€)**	**Irrigated Acres (m^2)**	**Withdrawals (m^3)**	**Cost/ acre**	**Cost/ m^3**
Meliti	47,498	13,517	3,379	64,394	3,800	1,103,520	16.95	0.058
Prespes	126,256	68,571	17,142	211,970	16,000	4,646,400	13.25	0.046
Limnochori	33,142	18,000	4,500	55,642	4,200	1,219,680	13.25	0.046
Sklithro	16,305	2,000	500	18,805	675	196,020	27.86	0.096
Petra	39,686	21,500	12,000	73,186	2,000	580,800	36.59	0.126
Regional Unit Pella	**Depreciation (€)**	**Operating Cost (€)**	**Maintenance Cost (€)**	**Total (€)**	**Irrigated Acres (m^2)**	**Withdrawals (m^3)**	**Cost/ acre**	**Cost/ m^3**
Edessaios	298,912	262,773	154,912	716,597	37,880	17,867,996	18.92	0.040
Regional Unit Kozani	**Depreciation (€)**	**Operating Cost (€)**	**Maintenance Cost (€)**	**Total (€)**	**Irrigated Acres (m^2)**	**Withdrawals (m^3)**	**Cost/ acre**	**Cost/ m^3**
Velvendo	387,869	319,569	22,330	729,770	16,000	8,684,800	45.61	0.084
Klima	6,433	9,984	1,243	17,661	300	164,648	58.87	0.107
Mesovouni	9,469	39,935	4,972	54,377	1,200	658,560	45.31	0.083
Neapoli	27,618	115,217	14,345	157,181	3,500	1,900,000	44.91	0.083
Servia	239,877	388,781	96794	725,453	12,300	6,585,600	58.98	0.110
Dafnero	1,578	6,655	828	9,062	200	109,760	45.31	0.083
Peponia	9,469	39,901	4,968	54,338	1,200	658,000	45.28	0.083
Chromio	4,734	21,224	2,642	28,601	600	350,000	47.67	0.082
Kaloneri-Eratyra	19,727	69,419 €	7,955	97,102	2,500	660,000	38.84	0.147
Pylorio	25,200	23,960	2,983	52,144	720	395,130	72.42	0.132
Imera	10,258	13,400	1,500	25,158	1,300	250,000	19.35	0.101
Mikrokastro	2,367	10,005	1,245	13,618	300	165,000	45.39	0.083
Mesiani	17,108	46,420	5,779	69,308	1,395	765,500	49.68	0.091
Molocha	2,367	8,000	400	10,767	300	164,640	35.89	0.065
Trapezitsa	4,924	20,769	2,586	28,279	624	342,500	45.32	0.083
Pyrgoi-Eordaia	47,916	53,970	6,719	108,606	1,620	890,000	67.04	0.122

Regional Unit Imathia	Depreciation (€)	Operating Cost (€)	Maintenance Cost (€)	Total (€)	Irrigated Acres (m^2)	Withdrawals (m^3)	Cost/ acre	Cost/ m^3
GOEB Thessaloniki-Lagada	1,186,904	64,138	279,911	1,530,953				
Tripotamos-Pediada	173,436	56,031	15,730	245,199	21,979	18,123,219	11.16	0.014
Trip. Veroia	303,757	498,154	144,982	946,893	38,494	22,589,280	24.60	0.042
Arapitsa	181,414	549,016	69045	799,476	22,990	17,926,584	34.77	0.045
Arapitsa Naousa	205,790	527,376	69,045	802,211	26,079	15,958,080	30.76	0.050
Agrok. Naousa	139,387	320,157	218,955	678,500	17,664	13,627,162	38.41	0.050
Rodchori	27,618	56,031	15,730	99,380	3,500	2,052,050	28.39	0.048
Regional Unit Pieria	**Depreciation (€)**	**Operating Cost (€)**	**Maintenance Cost (€)**	**Total (€)**	**Irrigated Acres (m^2)**	**Withdrawals (m^3)**	**Cost/ acre**	**Cost/ m^3**
Enipeas	25,424	41,595	29,439	96,460	3,222	1,441,523	29.94	0.067
Katachas	57,050	21,043	14,893	92,986	1,630	729,262	57.05	0.128
Kolindros	24,500	9,036	6,396	39,932	700	313,180	57.05	0.128
rachi	14,519	23,754	16,812	55,086	1,840	823,216	29.94	0.067
Eleytherochori	55,475	20,462	14,482	90,419	1,585	709,129	57.05	0.128
Ritini	25,093	25,863	18,305	69,262	3,180	896,321	21.78	0.077
Elatochori	15,387	25,174	17,817	58,379	1,950	872,430	29.94	0.067
Litochoro	48,766	79,783	56,467	185,017	6,180	2,764,932	29.94	0.067
Sevasti	45,045	16,615	11,759	73,419	1,287	575,804	57.05	0.128
Milia	10,573	20,545	16,585	47,703	1,340	599,516	35.60	0.080

Total financial cost, distributed in each respective River Basin of WD09, along with unit costs is presented in Table 6-19 (Ειδική Γραμματεία Υδάτων, 2014b).

Table 6-19: Total financial cost and weighted average costs for WD09 for the provisioning service (provision of agricultural water). Source: Ειδική Γραμματεία Υδάτων, 2014b

WD09 River Basins	Total Financial Cost (€)	Average Cost per acre (€/m^2)	Average Cost per m^3 (€/m^3)
Aliakmonas (GR02)	9,193,335 €	28.65 €	0.068 €
Prespes (GR01)	276,365 €	15.09 €	0.05 €
Total	9,469,700 €		

6.9 Estimation of Environmental Cost in the WD of Western and Central Macedonia

Environmental cost is defined as the valuation in monetary units of the environmental impacts for water resources and related ecosystems, caused by various socio-economic activities. The issue of economic valuation of environmental impacts does not have a direct and clear approach and this is why different estimation methodologies accompanied by corresponding restrictions have been proposed (Bithas, 2011). It is also important to note that the very relevance of the economic valuation of environmental pressures under certain conditions is often disputed (Bithas, 2011; Bromley, 1998). Nevertheless, monetization is still useful for internalizing the external costs of socioeconomic processes. This framework was followed to assess the pressures on aquatic ecosystems and resources of the Water Districts Central and Western Macedonia and its respective River Basins (Bithas et al., 2014).

Specific methodological frameworks have been proposed by the European authorities as well as by the National Monitoring Authority, the Special Secretariat for Water (WATECO, 2003; Working Group 2B, 2004; Ειδική Γραμματεία Υδάτων, 2012). The report of both Water Districts followed these standards and adapted them to the characteristics of the study area. More specifically, the selected method for the estimation of the environmental cost was that of the "avoidance cost" of the environmental impact/ pressure i.e. the "recovery cost" of the environmental impact that has already taken place. This method is clear on objective and can be directly applied (Bithas et al., 2014).

In addition, during the estimation of the environmental cost for both Water Districts a number of environmental pressures were observed, which could not be avoided or overcome. This is why it was attempted to estimate the environmental cost in those cases where avoidance or restoration was not feasible. Based on certain assumptions, those cases were correlated with other pressures that shared a number of common characteristics and avoidance and/or restoration was realizable. Such kind of approximation was carried out so as to avoid underestimation of such cases that would certainly lead to an inefficient policy proposal.

However, there were cases where the definition of cost was almost impossible, as "cause – effect" relationships between anthropogenic pressures and impacts on ecosystems and their ecological status could not be established. Additionally, it was not clear which were those socio-economic activities that could affect the ecological status of a water resource. In that case, the costs caused by such activities are usually ignored and not calculated. Nevertheless, this inevitably leads to biased estimates and to an erroneous allocation of environmental costs (Bithas et al., 2014).

In the respective Water Districts the environmental cost caused by any economic activity in the River Basins was estimated, even if "cause and effect" relationships could be identified. The basic assumption was that any activity that affects water resources and ecosystems creates impact-pressure, the cost of which is approximately equal to the "avoidance cost". For those cases where the cost of avoiding or treating that pressure could not be efficiently estimated, the respective cost of the more closely related activity was adopted(Bithas et al., 2014).

6.9.1 Estimation of the Environmental Cost the WD of Western and Central Macedonia: Methodology

The assessment of the significant pressures on the water bodies of both Water Districts was based on the detailed recording of all anthropogenic pressures (pressures of pollution, effects of extract quantities of water from the aquatic system, changes in the morphology of the water system, etc.). The aim was to understand on the one hand, the major management problems for each River Basin and on the other hand the mechanism by which each water body is affected.

More specifically environmental cost was estimated for the following cases:

- Lack or inefficient operation of wastewater treatment plants;
- industrial water use;
- (point or non-point source) pollution from agricultural use and;
- pollution by stabled livestock.

Firstly, for the estimation of the environmental cost, emanating from the lack or inefficient operation of wastewater treatment plants, it was firstly identified which specific municipalities were affected by it. After locating the municipalities, two sub- categories were identified

- Municipalities, where the installation of a wastewater treatment plant, along with the construction of a sewage system, was necessary and;
- Municipalities, where there exists a wastewater treatment plant, but lack the necessary infrastructure (sewage system).

For both cases, the methodology derived from a 2009 study of the former MEEC (ΕΜΒΗΣ, 2009a; 2009b), based on actual data relating to the construction of wastewater treatment facilities in Greece, that were financed under the Hellenic National Strategic Reference Framework.

As far as the capital costs are concerned, these were calculated as follows:

Construction of the sewage system (for areas with a population density less than 70 inhabitants/ hectare)

$$L = 2.75D + 60.58 \qquad (1)$$

where,

L, the necessary length of the sewage system in mm/hectare and;

D, population density in inhabitants/hectare.

For areas with a population density greater than 70 inhabitants/ hectare, L equals to 250mm/ hectare. Finally, the capital cost (in €) for the construction of the sewage system equals to:

$CC_{Sewage}= 250\ L$ (2)

Construction of a wastewater treatment facility

The capital cost (in €) was based on the following equation:

$CC_{Wastewatere}= 500P^{0.7}$ (3)

where P, the population served by the wastewater treatment plant in inhabitants.

In relation to the operational and maintenance cost (OEM) it was assumed that:

- for sewage system, it equals to 1.5% of the capital cost, with an estimated useful life of 50 years and a depreciation rate of 2% and;
- for the wastewater treatment facility, the OEM equals to 2% of the capital cost, with an estimated useful life of 50 years and a depreciation rate of 2%.

Secondly, it was assumed that the environmental cost caused by the use of water in industries equals to the cost of building facilities treating industrial wastewater. More specifically, the annual cost of treating wastewater from industrial use was based on the equation:

$\lambda= 1.03Q^{-0.3}$ (4)

where

λ, the cost per m^3 in €/ m^3

Q, the daily water inflow in m^3

Thirdly, a challenging task was the estimation of the pollution from agricultural use. It was assumed that the environmental cost of point pollution equals to the creation of a constructed wetland and amounts to €1.3 /acre/year or €0,003/m^3.

Concerning the environmental cost of non-point pollution in areas that there is no drainage system, this amounts to €0.65 /acre/year (half of the environmental cost of point source pollution).

Fourthly, pollution from stabled livestock, an identical approach with that of the industrial water use was followed.

6.9.2 Estimation of Environmental Cost in the WD of Central Macedonia- Results

Provisioning service (freshwater provision)

In chapter 4.6.1 four distinct categories of environmental cost have been identified. Based on the assumptions stated in chapter 4.3, the first two environmental cost categories should be added to the estimation of the provisioning service (freshwater provision), as they are directly linked to the related water use.

In WD10, there are 37 Wastewater Treatment Plants (WWTPs), the largest of which is the Thessaloniki Waste Water Treatment Plant, which serves more than 1.3 million equivalent inhabitants. The rest of the WWTPs serve settlements of over 2,000 equivalent residents up to 90,000 m^3 (Ειδική Γραμματεία Υδάτων, 2014a).

According to other related studies (Ειδική Γραμματεία Υδάτων, 2014c) , there are cases where there is need for the installation of WWTPs as well as additional sewerage networks for their interconnection either with existing WWTPs or with new ones (Ειδική Γραμματεία Υδάτων, 2014c).

Peak population of the WD10 was estimated at approximately 1,390 thousand (agglomerations with more than 2,000 inhabitants). 88,6% of the population is connected with WWTPs and 11,4% by appropriate individual sewerage systems. A percentage of these effluents are accepted by the WWTPs of the agglomerations, as mentioned above. Based on Ειδική Γραμματεία Υδάτων (2014e) all Priority A and B settlements are served by WWTPs. The 25 priority C agglomerations which are served by other sewerage systems (SDSs) and do not currently have WWTPs will be served by the realization of infrastructure projects for collection and treatment of urban waste water.

The results for WD10 concerning the lack or inefficient operation of wastewater treatment plants are presented in Table 6-20.

Table 6-20: Total environmental cost (lack or inefficient operation of wastewater treatment plants) for WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Settlement	Aggregate Annual Cost Sewerage Infrastructure (€)	Aggregate Annual Cost for the construction of WWTP (€)	Aggregate Annual Cost (€)	Aggregate Annual Cost per person (€)

Settlement	Aggregate Annual Cost Sewerage Infrastructure (€)	Aggregate Annual Cost for the construction of WWTP (€)	Aggregate Annual Cost (€)	Aggregate Annual Cost per person (€)
Ag. Nikolaos Sithonias	80,732	-	80,732	23 €
Adendro	93,229	40,439	133,669	59 €
Alexandria Imathia	753,799	-	753,799	34 €
Anatoliko	66,910	-	66,910	26 €
Arnaia	-	54,085	54,085	24 €
Asvestochori	27,833	-	27,833	4 €
Assiros	137,292	-	137,292	59 €
Afytos	204,527	-	204,527	49 €
Bathylakkos	90,410	-	90,410	41 €
Basilika	98,007	-	98,007	25 €
Galatades	88,066	54,842	142,908	61 €
Galatista	22,915	64,883	87,798	30 €
Gefyra	125,571	-	125,571	39 €
Goumenissa	-	80,859	80,859	20 €
Dionyssios	83,870	-	83,870	14 €
Eyropos	30,461	-	30,461	13 €
Zagliveri	29,474	54,381	83,855	36 €
Thessaloniki	10,969,588	-	10,969,588	9 €
Thessaloniki-Touristic	545,192	-	545,192	10 €
Kalyves	420,197	113,783	533,980	80 €
Koufalia	84,000	-	84,000	10 €
Kryopigi	162,004	-	162,004	51 €
Kymina	89,348	75,487	164,835	45 €
Lagyna	142,318	-	142,318	59 €
Mygdonia	200,296	-	200,296	38 €
Megali Panagia	0	61,062	61,062	22 €
Mylotopos	118,096	-	118,096	45 €

Settlement	Aggregate Annual Cost Sewerage Infrastructure (€)	Aggregate Annual Cost for the construction of WWTP (€)	Aggregate Annual Cost (€)	Aggregate Annual Cost per person (€)
Nea Malgara	65,042	56,538	121,579	50 €
Nea Mesimvria	95,220	-	95,220	41 €
Nea Moydania	413,607	-	413,607	30 €
Nea Plagia	98,675	-	98,675	35 €
Nea Roda	146,023	-	146,023	68 €
Nea Triglia	101,720	-	101,720	35 €
Pella	91,415	56,651	148,065	60 €
Plagiari	94,690	-	94,690	25 €
Platy	92,733	54,184	146,917	64 €
Polygyros	0	94,812	94,812	19 €
Polykastro	112,185	149,951	262,135	27 €
Simantra	90,065	118,818	208,883 €	83 €
Stayros	417,917	122,211	540,127	74 €
Sykia	118,892	-	118,892	51 €
Trilofos	89,510	72,964	162,474	46 €
Flogita	231,194	-	231,194	31 €
Chalastra	183,800	-	183,800	25 €
Chalkidona	141,858	57,226	199,084	53 €
Chortiatis	0	64,455	64,455	22 €
Total			18,696,309	

Concerning industrial use, based on the methodology described in chapter 6.9.1, the results are summarized in Table 6-21.

Table 6-21: Total environmental cost (industrial use) for WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Municipality	Total Annual Cost (€)
Mikra	20,779 €
Gallikos	180,928 €
Platy	48,206 €
Lagada	98,865 €
Kallithea	144,354 €

Kallikrateia	21,049 €
Eykarpia	76,360 €
Axios	11,891 €
Koyfalia	137,928 €
Pikrolimni	12,561 €
Axioupoli	49,133 €
Echedoros	89,881 €
Oraiokastro	117,796 €
Mygdonia	90,072 €
Kalamaria	7,313 €
Kassadra	7,689 €
Kilkis	7,974 €
Kallikrateia	27,088 €
Krya Vrysi	12,228 €
Anthemounta	12,526 €
Vasilika	52,172 €
Meg. Alexandros	10,786 €
Kyrros	53,857 €
Giannitsa	47,767 €
Koyfalia	32,014 €
Polygyros	48,085 €
Eirinoupoli	95,672 €
Alexandria	48,949 €
Platy	39,531 €
Antigonides	32,267 €
Polykastro	12,607 €
Giannitsa	123,354 €
Triglia	14,514 €
Total	1,786,196 €

The total environmental cost for this provisioning service and how this is shared in each RB will be presented Table 6-22 .

Table 6-22: Total Environmental cost for the provisioning service (freshwater provision) in WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Environmental Cost Categories	Axios	Gallikos	Chalkidiki	Athos	Total WD10
WWTPs	3,971,524 €	1,297,069 €	13,427,716 €	- €	18,696,309 €
Industrial Use	776,725 €	532,959 €	476,513 €	- €	1,786,197 €
Total	4,748,249 €	1,830,028 €	13,904,229 €	- €	20,482,506 €

6.9.3 Estimation of Environmental Cost in the WD of Central Macedonia- Results

Provisioning service (provision of agricultural water)

Point or non-point source pollution from agricultural use and pollution by stabled livestock are the two environmental cost categories that will be added to the provisioning service (provision of agricultural water).

Point source pollution concerns pollution that is assumed to come from organized farming i.e. TOEBs. Therefore, the environmental cost of point pollution equals to the creation of a constructed wetland. The cost of wetland construction was based on the construction of the Lake Karla in Magnisia, Greece and a Benefit transfer approach was employed.

In relation to non-point pollution, is equally important as it affects the state of both surface and groundwater bodies and therefore it is necessary to take account of them (Ειδική Γραμματεία Υδάτων, 2014a). Based on expert interviews, non-point pollution environmental cost is equal to 50% of the point source pollution environmental cost (Ειδική Γραμματεία Υδάτων, 2014a). Furthermore, it was also assumed that non-point pollution in non-organised farming and in organized farming, where there is no drainage infrastructure available (Ειδική Γραμματεία Υδάτων, 2014a).

Table 6-23: Total point and non-point pollution environmental cost for WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Regional Unit	Irrigated Surface- Organised Farming (Acres)	Annual Construction Cost (point pollution- €)	Surface of private farming (Acres)	Annual Construction Cost (non-point pollution- €)
Thessaloniki	327,488	468,308 €	266,208	173,035 €
Imathia	298,213	426,445 €	98,198	63,829 €
Kilkis	55,330	79,122 €	92,884	60,375 €
Pella	164,719	235,548 €	328,841	213,747 €
Chalkidiki	0	- €	128,360	83,434 €
		1,209,423 €	**914,491**	**594,420 €**

Additionally, pollution for stabled livestock follows the same methodology as industrial use.

Table 6-24: Total environmental cost for stabled livestock in WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a)

Regional Unit	Water Consumption (m^3)	Annual Cost (€)
Thessaloniki	4,016,989	253,662 €
Pella	658,069	71,501 €
Imathia	422,656	52,446 €
Kilkis	2,074,910	159,744 €
Chalkidiki	1,669,080	137,170 €
	8,841,705	**674,523 €**

The total environmental cost for this provisioning service and how this is shared in each RB will be presented Table 6-25.

Table 6-25: Total Environmental cost for the provisioning service (provision of agricultural water) in WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a

Environmental Cost Categories	Axios	Gallikos	Chalkidiki	Athos	Total WD10
Organised Irrigation	1,177,248 €	17,732 €	14,443 €	- €	1,209,423 €
Private Irrigation	374,768 €	32,397 €	187,255 €	- €	594,420 €
Stabled Livestock	269,122 €	65,302 €	340,100 €	- €	674,524 €
Total	1,821,138 €	115,431 €	541,798 €	- €	2,478,367 €

6.9.4 Estimation of Environmental Cost in the WD of Western Macedonia-Results Provisioning service (freshwater provision)

The same methodological approach is applied to WD09. In WD09, there are 15 Wastewater Treatment Plants (WWTPs), the largest of which is the Katerini Waste Water Treatment Plant, which serves more than 130 thousand equivalent inhabitants (Ειδική Γραμματεία Υδάτων, 2014b).

Peak population of the WD10 was estimated at approximately 470 thousand (agglomerations with more than 2,000 inhabitants). 83% of the population is connected with WWTPs and 17% by appropriate sewerage systems. A percentage of these effluents are accepted by the WWTPs of the agglomerations, as mentioned above. Based on Ειδική Γραμματεία Υδάτων (2014f) all Priority A and B settlements are served by WWTPs. The 19 priority C agglomerations which are served by other sewerage systems (SDSs) and do not currently have WWTPs will be served by the realisation of infrastructure projects for collection and treatment of urban waste water (Ειδική Γραμματεία Υδάτων, 2014b).

The results for WD09 concerning the lack or inefficient operation of wastewater treatment plants and industrial use are presented in Table 6-26 and Table 6-27 respectively.

Table 6-26: Total environmental cost (lack or inefficient operation of wastewater treatment plants) for WD10. Source: Ειδική Γραμματεία Υδάτων, 2014b

Settlement	Aggregate Annual Cost Sewerage Infrastructure (€)	Aggregate Annual Cost for the construction of WWTP (€)	Aggregate Annual Cost (€)	Aggregate Annual Cost per person (€)
Aiani	99,411	-	99,411	48
Amyntaio	247,137	-	247,137	55
Aridaia	-	102,306	102,306	18
Velvento	-	72,674	72,674	21
Brontou	92,552	-	92,552	44
Galatini	-	50,720	50,720	24
Grevena	853,527	-	853,527	81
Karitsa	97,844	-	97,844	44
Kastoria	1,296,118	-	1,296,118	46
Katerini	2,850,051	-	2,850,051	23
Kozani	2,614,390	-	2,614,390	42
Kolindros	170,192	-	170,192	47
Kopanos	79,898	-	79,898	37
Krokos	123,035	-	123,035	42
Litochoro	2,421,651	-	2,421,651	44
Makrygialos	125,725	-	125,725	47
Meliki	121,633	66,825	188,458	61
Naousa	819,847	-	819,847	37
Neapoli	82,412	-	82,412	35
Servia	-	69,635	69,635	21
Siatista	138,702	-	138,702	25
Skydra	172,280	-	172,280	34
Florina	1,020,500	-	1,020,500	49
Total			13,789,065	

Table 6-27: Total environmental cost (industrial use) for WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

Municipality	Total Annual Cost
Elafina	15,864 €
Edessa	52,971 €
Paralia	12,511 €
Meliti	6,845 €
Dovra	23,015 €
Aridaia	51,151 €
Naousa	291,274 €
Veroia	237,405 €
Anthemia	55,594 €
Vitsi	11,032 €
Meniida	22,846 €
Dion	30,065 €
Korinos	30,613 €
Katerini	47,980 €
Anthemia	51,294 €
Skydra	80,323 €
Makednon	20,536 €
Ptolemaida	11,401 €
Grevena	15,924 €
Meliki	15,443 €
Livadero	9,671 €
Litochoro	9,671 €
Meg. Alexandrou	12,429 €
	1,115,858 €

The total environmental cost for this provisioning service and how this is shared in each RB is presented in Table 6-28.

Table 6-28: Total Environmental cost for the provisioning service (freshwater provision) in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

Environmental Cost Categories	Aliakmonas	Prespes	Subbasin Prespes	Total WD09
WWTPs	12,902,829 €	886,238 €	- €	13,789.066 €
Industrial Use	1,109,013 €	6,845 €	- €	1,115,858 €

Total	**14,011,842 €**	**893,083 €**	**- €**	**14,904,924 €**

6.9.5 Estimation of Environmental Cost in the WD of Western Macedonia- Results Provisioning service (provision of agricultural water)

As in chapter 6.9.2 the identical methodology is employed as in WD10 and results are presented in Table 6-29 and Table 6-30.

Table 6-29: Total point and non-point pollution environmental cost for WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

REGIONAL UNIT	Annual Construction Cost (point pollution- €)	Surface of organised farming (without drainage infrastructure- non-point pollution-Acres)	Surface of private farming (Acres)	Total Surface For Non-Point Pollution (Acres)	Annual Construction Cost (non-point pollution- €)
Grevena	34,573 €	2,790	30,370	33,160	25,533 €
Kastoria	43,164 €	7,269	23,055	30,324	23,349 €
Florina	82,159 €	0	147,266	147,266	113,395 €
Pella	58,335 €				
Kozani	63,508 €	2,860	87,776	90,636	69,790 €
Imathia	195,897 €	3500		3,500	2,695 €
Pieria	20,508 €	5807	170,979	176,786	136,125 €
Total	**498,144 €**	**22,226**	**459,446**	**481,672**	**370,887 €**

Table 6-30: Total environmental cost for stabled livestock in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Regional Unit	Water Consumption (m^3)	Annual Cost (€)
Kastoria	496,765	58,726 €
Grevena	635,330	69,763 €
Kozani	1,616,051	134,105 €
Imathia	980,495	94,523 €
Pella	1,714,325	139,762 €
Pieria	3,112,434	212,175 €
Florina	1,263,862	112,905 €
Total	**9,819,262**	**821,959 €**

The total environmental cost for this provisioning service and how this is shared in each RB is presented in Table 6-31.

Table 6-31: Total environmental cost for the provisioning service (provision of agricultural water). Source: Ειδική Γραμματεία Υδάτων, 2014b.

Environmental Cost Categories	Aliakmonas	Prespes	Subbasin Prespes	Total WD09
Organised Irrigation	441,844 €	82,159 €	24,640 €	524,003 €
Private Irrigation	231,634 €	113,395 €	14,741 €	345,029 €
Stabled Livestock	709,054 €	112,906 €	14,678 €	821,960 €
Total	1,382,532 €	308,460 €	54,059 €	1,690,992 €

6.10 Estimation of Resource Cost in the WD of Western and Central Macedonia

Resource cost refers to the foregone benefits that are due either to the inefficient allocation of water resources or the excessive use of water resources, i.e. water withdrawals greater than the renewable water reserves. Consequently, the resource cost equals to the foregone benefits of the service that is deprived of the use of the particular natural resource, while under conditions of effective allocation this would have not have happened. It is true that in a number of cases this is the service that provides the highest socio-economic benefits (Ειδική Γραμματεία Υδάτων, 2014a). This is why the framework proposed by relevant European documents could be used so as to accurately estimate the context of resource cost in the respective Water Districts ((WATECO, 2003; Working Group 2B, 2004).

In the case of the Water Districts of Central and Western Macedonia, resource cost is associated with the use of water at a greater level than the rate of their natural renewal. This means that water use deprives water stocks from the future and this is why it can be characterized as an intertemporal foregone benefit. In that way, resource cost refers to the cost caused by the "excessive" use beyond the socioeconomic optimal level which is by convention identical to the level of the resource's renewal (Ειδική Γραμματεία Υδάτων 2014a).

In accordance with the above mentioned assumptions, resource cost is "caused" by an institutional framework that dictates the hierarchy of uses as well as the basic allocation of the resource. The institutional framework is an administrative framework which sets clear priority to the use of water and intervenes, where necessary, to allocate resources. Also, this framework has no substantial relationship to the existence of a market for the natural resource, as the existing pricing mechanisms are determined administratively (Ειδική Γραμματεία Υδάτων, 2014a).

All in all, resource cost equals to the foregone benefits caused by a hypothetical restriction of water use to the water renewal rates. Those foregone benefits will be estimated by restricting the use that yields the smaller benefits. It is therefore assumed that water demand for all other uses that yield proportionally greater benefits is satisfied in priority (Bithas, 2008; Briscoe, 1997; Pearce, 1999).

6.10.1 Estimation of the Resource Cost in Water Districts of Central and Western Macedonia: Methodology

According to Special Secretariat for Water (Ειδική Γραμματεία Υδάτων 2014a), existing resource cost is operationally assessed as an opportunity cost of the water resources deficit. Apart from that, the amount of water deficit is determined both spatially and temporally.

Distinctive opportunity costs caused by the excessive use of water resources are associated with the gradual reduction of groundwater stocks in some areas, which creates a timeless rarity. Therefore, future withdrawals will be impossible to be satisfied as they have a drastically reduced underground water reserve at their disposal. Consequently, there is an opportunity cost equal to the benefits of future uses that could be met, given that such future uses could exploit water resources to a rate a least equal to the renewal rate of the aquifer, thus without reducing the corresponding stocks. The same goes for the current period, i.e. when water stocks are not reduced, no opportunity cost and therefore no cost resource exists (Ειδική Γραμματεία Υδάτων, 2014a).

Firstly, so as to estimate the opportunity costs brought about by the reduction of groundwater stocks, it was assumed that future economic conditions are proportional to the current ones. Therefore, opportunity cost is considered as the cost of avoiding the creation of intertemporal rarity caused by the current socio-economic activities. In other words, the cost is equal to the current foregone benefits from the restriction of less economically efficient use. At that point, it should be noted that this restriction is imposed so as not to prevent the aquifer's apparent depletion (Ειδική Γραμματεία Υδάτων, 2014a).

The operational assessment for both Water Districts was based on the hypothesis that the restriction of water use will be implemented in the agricultural water use in irrigated areas. Therefore, the cost equals to the foregone benefits of converting the respective areas of irrigated crops in rainfed ones (dry land farming). The size of the areas as well as the crops converted to rainfed is determined by the area that is hypothetically irrigated by the annual groundwater reserve deficit (exceeding the rate of water renewal (Ειδική Γραμματεία Υδάτων, 2014a).

The water use that was responsible for the deficit of the groundwater reserves of the respective water body in both Water Districts was mainly the agricultural use (organized and private), household use, industrial and mining use and livestock use. This fact confirms the primary assumption and estimation method presented above. Nevertheless, it should be noted that the main user of groundwater reserves is agriculture but not organized farming (under the local and regional Land Declaration Associations) but individual farmers that take water from drilling. For that reason and according to the “polluter –pays-principle”, the estimated resource cost should be distributed accordingly to each user.

6.10.2 Estimation of the Resource Cost in Water Districts of Central Macedonia: Results

The estimation of resource cost is directly linked with all related water uses in both WDs. Consequently, one cannot a priori assume that the total sum of the resource cost is attributed to solely one water use. For that reason, the resource cost will be firstly estimated as a whole and secondly this sum will be weighted accordingly to all water uses in the WD. Indirectly, this means that the weight of each water use reflects how much is this water use responsible for the deficit of the groundwater reserves.

Based on Ειδική Γραμματεία Υδάτων (2014e), the deficit of groundwater reserves is estimated at 77.470.000 m^3, which equal to potentially irrigated land (82.262 ha). The cost of crop transition from irrigated to dry, for potentially irrigated land is then calculated (Ειδική Γραμματεία Υδάτων, 2014a).

Firstly, the quantity of the groundwater deficit is calculated in absolute numbers (m^3) for each groundwater body in each RB.

Table 6-32: Groundwater deficit in Groundwater Bodies in WD10 for each water use. Source: Ειδική Γραμματεία Υδάτων, 2014a.

RB	Groundwater Body (GB)	Drinking Water	Irrigation	Industry	Livestock	Total	Renewable Reserves	Balance of deficient GBs
Axios	GR1000030	13.16	134.52	7.55	1.09	156.33	134	-22.33
Axios	GR100F040	0.96	13.67	0.16	0.08	14.88	8.3	-6.58
Gallikos	GR1000050	3.51	34.61	12.63	0.92	51.67	35	-16.67
Chalikidiki	GR1000060	4.56	115.7	0.85	0.21	121.32	97.83	-23.49
Chalkidiki	GR1000080	9.71	25.32	1.77	0.21	37.02	33.6	-3.42
Chalkidiki	GR1000100	0.1	11.29	0	0	11.39	7.25	-4.14
Chalkidiki	GR1000180	4.72	12.92	0.01	0.19	17.84	17	-0.84
Total		**36.71**	**348.04**	**22.97**	**2.72**	**410.45**	**332.98**	**77.47**

Secondly, the estimation of potential irrigated land, based of groundwater deficiency follows.

Table 6-33: Demand for irrigated land per GB according to the quantities of groundwater deficit in WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

RB	Groundwater Body (GB)	Groundwater Deficit (m^3)	Demand of Irrigated Water per acre (m^3/ acre)	Irrigated land (m^2)
Axios	GR1000030	22.33	819	27,265
Axios	GR100F040	6.58	819	8,034
Gallikos	GR1000050	16.67	1034	16,122
Chalikidiki	GR1000060	23.49	1034	22,718
Chalkidiki	GR1000080	3.42	1034	3,307
Chalkidiki	GR1000100	4.14	1034	4,004
Chalkidiki	GR1000180	0.84	1034	812
Total		**77.47**		**82,262**

Thirdly, the cost transition of crop transition from irrigated to dry farming is calculated.

Table 6-34: Cost transition of crop transition from irrigated to dry farming in WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

	Crops	Area (in acres)	Mean production (in Kg/acres)	Total production (tn)	Unit cost (€/Kg)	Total value (€)	Cultivation conversion cost in €	Loss weight
Irrigated	Grapevine	82,262	2,000 €	164,524 €	0.34 €	55,938,160 €		
Rainfed	Grapevine	82,262	800 €	65,810 €	0.34 €	22,375,264 €	33,562,896 €	40%
Irrigated	Nuts	146,338	500 €	41,131 €	1.70 €	69,922,700 €		
Rainfed	Nuts	146,338	450 €	37,018 €	1.70 €	62,930,430 €	6,992,270 €	90%
Irrigated	Beans	146,338	250 €	20,566 €	1.50 €	30,848,250 €		
Rainfed	Beans	146,338	150 €	12,339 €	1.50 €	18,508,950 €	12,339,300 €	60%

Resource Cost is finally estimated as the weighted average of the Crop Transition cost, which is estimated at 17,631,489 € (Ειδική Γραμματεία Υδάτων, 2014a).

It is noted that after the estimation of the organized irrigation withdrawals, about 1% of the total irrigation yields, which is the main source of groundwater, emerges. This means that the main users of groundwater bodies for irrigation are individuals (boreholes) and therefore resource cost must be allocated proportionally to them. In addition, the unit resource cost for WD10 is 0.04 € and is allocated to the different uses according to the percentage of withdrawals for each of them.

Table 6-35: Allocation of resource cost and unit resource cost per water use in RBs of WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

RB	Irrigation €	Organised Irrigation	Private Irrigation	Water Supply	Industry	Stabled Livestock	Total
Axios	6,365,935 €	63,659 €	6,302,276 €	606,422 €	331,268 €	50,615 €	7,354,240 €
Gallikos	1,486,907 €	14,869 €	1,472,038 €	150,699 €	542,428 €	39,660 €	2,219,694 €
Chalkidiki	7,097,747 €	70,977 €	7,026,770 €	820,009 €	112,857 €	26,678 €	8,057,292 €
Total	**14,950,589 €**	**149,506 €**	**14,801,084 €**	**1,577,130 €**	**986,554 €**	**116,953 €**	**17,631,227 €**
Unit Resource Cost	0.030	0.000	0.030	0.000	0.002	0.000	0.040
Percentage	85%	1%	84%	9%	6%	1%	100%

6.10.3 Estimation of the Resource Cost in Water Districts of Western Macedonia: Results

Based on Ειδική Γραμματεία Υδάτων (2014f), the deficit of groundwater reserves is estimated at 60.360.000 m^3, which equal to potentially irrigated land (73.700 acres). The cost of crop transition from irrigated to dry, for potentially irrigated land is then calculated (Ειδική Γραμματεία Υδάτων, 2014a).

Firstly, the quantity of the groundwater deficit is calculated in absolute numbers (m^3) for each groundwater body in each RB

Table 6-36: Groundwater deficit in Groundwater Bodies in WD09 for each water use. Source: Ειδική Γραμματεία Υδάτων, 2014b.

	Groundwater Body	Water Supply	Irrigation	Industry	Stabled Livestock	Total
Aliakmonas	GR0900060	6.8	57.28	0.24	0.17	75.88
Aliakmonas	GR0900150	3.1	45.36	0.63	1.41	50.5
Aliakmonas	GR0900160	1.35	51.23	0.18	1.23	53.98
Total		**11.25**	**153.87**	**1.05**	**2.81**	**180.36**

Secondly, the estimation of potential irrigated land, based of groundwater deficiency follows.

Table 6-37: Demand for irrigated land per GB according to the quantities of groundwater deficit in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

RB	Groundwater Body (GB)	Groundwater Deficit (m^3)	Demand of Irrigated Water per acre (m^3/ acre)	Irrigated land (m^2)
Aliakmonas	GR0900060	25.88	819	31,600
Aliakmonas	GR0900150	10.5	819	12,821
Aliakmonas	GR0900160	23.98	819	29,280
Total		**60.36**		**73,700**

Thirdly, the cost transition of crop transition from irrigated to dry farming is calculated.

Table 6-38: Cost transition of crop transition from irrigated to dry farming in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

Crops	Area (in acres).	Mean production (Kg/acres)	Total production (tn)	Unit cost (€/Kg)	Total value (€)	Cultivation conversion cost (€)
Grapevine	73,700	2,000 €	147,399 €	0.34 €	50,115,751.00 €	
Grapevine	73,700	800 €	58,960 €	0.34 €	20,046,300.00 €	30,069,451 €
Nuts	73,700	500 €	36,850 €	1.70 €	62,644,689.00 €	
Nuts	73,700	450 €	33,165 €	1.70 €	56,380,220.00 €	6,264,469 €
Beans	73,700	250 €	18,425 €	1.50 €	27,637,363.00 €	
Beans	73,700	150 €	11,055 €	1.50 €	16,582,418.00 €	11,054,945 €

Resource Cost is finally estimated as the weighted average of the Crop Transition cost, which is estimated at 15.796.288 € (Ειδική Γραμματεία Υδάτων, 2014b) which is allocated as follows.

Table 6-39: Allocation of resource cost and unit resource cost per water use in RBs of WD10. Source: Ειδική Γραμματεία Υδάτων, 2014b.

RB	Water Supply	Organised Irrigation	Private Irrigation	Industry	Mining (PPC S.A.)	Stabled Livestock	Total
Aliakmonas	**985,297 €**	**1,347,624 €**	**12,128,617 €**	**91,961 €**	**996,683 €**	**246,105 €**	**15,796,288 €**
Percentage	6%	9%	77%	1%	6%	2%	100%
Unit Resource Cost	0.01 €	0.01 €	0.07 €	0.00 €	0.01 €	0.00 €	0.09 €

6.11 Estimation of the provisioning service (freshwater provision) in the Water Districts of Central and Western Macedonia

In the previous chapters, all related categories concerning the total value of water were estimated. By summing up those cost categories i.e. financial, environmental and resource, one could assume that this is equal to the total value of the related ecosystem services provided in the specific geographic regions, in our case Water Districts.

In relation to WD10 the results are presented in Table 6-40:

Table 6-40: Estimation of the provisioning service (freshwater provision) in WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Cost Categories	Axios (€)	Gallikos (€)	Chalikidi (€)	Athos (€)	Total WD10 (€)
Financial Cost (Water Supply)	19,611,330 €	8,055,555 €	79,190,082 €	885,704 €	107,742,671 €
Financial Cost (Industry)		7,231,586 €			7,231,586 €
Environmental Cost (Water Supply)	3,971,524 €	1,297,069 €	13,427,716 €	- €	18,696,309 €
Environmental Cost (Industry)	776,725 €	532,959 €	476,513 €	- €	1,786,197 €
Resource Cost (Water Supply)	606,422 €	150,699 €	820,009 €	- €	1,577,130 €
Resource Cost (Industry)	331,268 €	542,428 €	112,857 €	- €	986,554 €
Total	**25,297,269 €**	**17,810,296 €**	**94,027,177 €**	**885,704 €**	**138,020,447 €**

Total cost of the provisioning service (freshwater provision) is estimated at approximately 138 million €. The WB of Chalkidiki shows the highest value of the estimated ecosystem service, as this is where the metropolitan area of Thessaloniki is located.

In relation to WD09 the results are presented in **Table 6-41**:

Table 6-41: Estimation of the provisioning service (freshwater provision) in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

Cost Categories	Aliakmonas (€)	Prespes (€)	Subbasin Prespes (€)	Total WD09 (€)
Financial Cost (Water Supply)	51,745,540 €	2,473,450 €	80,944 €	54,218,990 €
Environmental Cost (Water Supply)	12,902,829 €	886,238 €	- €	13,789,066 €

Cost Categories	Aliakmonas (€)	Prespes (€)	Subbasin Prespes (€)	Total WD09 (€)
Environmental Cost (Industry)	1,109,013 €	6,845 €	- €	1,115,858 €
Resource Cost (Water Supply)	985,297 €	-€	-€	985,297 €
Resource Cost (Industry)	1,088,644 €	-€	-€	1,088,644 €
Total	67,831,323 €	3,366,533 €	80,944 €	71,197,855 €

In WD09, the Aliakmonas RB occupies almost all the geographic area of WD09. Therefore, the value of the ecosystem service in that RB is more than 95% of the total value of the service in the WD09.

6.12 Estimation of the provisioning service (provision of agricultural water) in the Water Districts of Central and Western Macedonia

The same methodology is followed for the estimation of the ecosystem service provision of agricultural water in both WDs.

In relation to WD10 the results are shown in **Table 6-42**:

Table 6-42: Estimation of the provisioning service (provision of agricultural water) in WD10. Source: Ειδική Γραμματεία Υδάτων, 2014a.

Cost Categories	Axios (€)	Gallikos (€)	Chalikidi (€)	Athos (€)	Total WD10 (€)
Financial Cost (Organised Irrigation)	28,788,494 €	243,841 €	109,038 €	- €	29,141,373 €
Environmental Cost (Organised Irrigation)	1,177,248 €	17,732 €	14,443 €	- €	1,209,423 €
Environmental Cost (stabled livestock	269,122 €	65,302 €	340,100 €	- €	674,524 €
Environmental Cost (Private Farming)	374,768 €	32,397 €	187,255 €	- €	594,420 €
Resource Cost (Organised Irrigation)	63,659 €	14,869 €	70,977 €	- €	149,506 €

Cost Categories	Axios (€)	Gallikos (€)	Chalikidi (€)	Athos (€)	Total WD10 (€)
Resource Cost (Private Farming)	6,302,276 €	1,472,038 €	7,026,770 €	- €	14,801,084 €
Resource Cost (Stabled Livestock)	50,615 €	39,660 €	26,678 €	- €	116,953 €
Total	**37,026,182 €**	**1,885,839 €**	**7,775,261 €**	**- €**	**46,687,283 €**

Total value of the provisioning service (provision of agricultural water) is estimated at more than 46 million €. Axios RB shows the greatest value as this is where the majority of basically organized farming is located.

Table 6-43 shows the results for WD09:

Table 6-43: Estimation of the provisioning service (provision of agricultural water) in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b.

Cost Categories	Aliakmonas (€)	Prespes (€)	Subbasin Prespes (€)	Total WD09 (€)
Financial Cost (Organised Irrigation)	9,193,335 €	276,365 €	211,970 €	9,469,701 €
Environmental Cost (Organised Irrigation)	441,844 €	82,159 €	24,640 €	524,003 €
Environmental Cost (stabled livestock	709,054 €	112,906 €	14,678 €	821,960 €
Environmental Cost (Private Farming)	231,634 €	113,395 €	14,741 €	345,029 €
Resource Cost (Organised Irrigation)	1,347,624 €	-€	-€	1,347,624 €
Resource Cost (Private Farming)	12,128,617 €	-€	-€	12,128,617 €
Resource Cost (Stabled Livestock)	246,105 €	-€	-€	246,105 €
Total	**24,298,213 €**	**584,825 €**	**266,029 €**	**24,883,039 €**

As with the previous estimation, almost all the value of the ecosystem service (provision of agricultural water) is attributed to Aliakmonas RB, as the RB Prespes is located in a remote and small geographic area.

6.13 Estimation of the provisioning service (water for electricity use) in the Water Districts of Western Macedonia

Public Power Corporation's (PPC) activity in the study area (RB Aliakmonas) required special consideration of the use of water for both energy production and other water-utilization activities. PPC's related activities related to the use of water resources consist of the operation of 6 Lignite Fire Power Stations, the operation of large hydroelectric projects, water discharges from PPC mines and the parallel use of reservoir water for irrigation needs (mainly for organized irrigation) and in some cases water supply. It was therefore necessary to independently examine the socio-economic impacts of the use of water resources by PPC through a meaningful assessment of the relative benefits and costs they cause.

The main socio-economic components taken into account are the following (Ειδική Γραμματεία Υδάτων, 2014b):
The Financial Cost of Large Hydroelectric Power Plants along Aliakmonas upstream and downstream of Lake Polyfyto.

- The Resource Cost generated by the uses of PPC's mining water.
- PPC revenues from the value of hydroelectric power produced.
- The benefit of avoiding the release of CO_2 from the production of hydropower.
- The benefit of water holdings from HNV barriers for irrigation needs.

6.13.1 Estimation of the provisioning service (water for electricity use) in the Water Districts of Western Macedonia- Methodology and Results

Firstly, the financial cost of PPC's activities were estimated. These equal to what it was estimated to be the annual cost of depreciation of large hydroelectric power plants (2% of total construction costs) as well as the operating costs of those power plants (2,5% of total construction cost). For the power plants, where no data were available, the corresponding cost were calculated on existing data (Ειδική Γραμματεία Υδάτων, 2014b).

Table 6-44: Total financial cost for PPC's activities in WD09. Source: Ειδική Γραμματεία Υδάτων, 2014b

Large hydroelectric power plants	Annual Depreciation Cost (€)	Annual Operating Cost (€)	Total Financial Cost (€)
Polyfytos	1,058,854 €	924,830 €	1,983,684 €
Ilarionas	5,635,100 €	7.043,875 €	12,678,975 €
Sfikia	5,332,051 €	6,665,063 €	11,997,114 €
Total	**12,961,125 €**	**15,802,668 €**	**28,763,791 €**

Additionally, a resource cost, which was estimated at 996.683 € should also be taken into consideration (Ειδική Γραμματεία Υδάτων, 2014b).

Apart from that, PPC's activities related to water in the WD09 bring about benefits that should also be estimated.

Firstly, large hydroelectric power plants produce electricity, which is fed into the grid. For the estimation of this benefit the following assumptions were made (Ειδική Γραμματεία Υδάτων, 2014b) :

The peak demand times are:

- In the winter months, from October to April, at 10 am-2pm and 6:30pm-10:30pm, i.e. 8 hours in total.
- In the summer months from May to September from 11am to 11pm, i.e. 12 hours in total.

Large Hydro, thanks to the large storage volumes of their reservoirs, generate 90% energy at the peak of demand, while only 10% of their operating time is out of peak hours (PPC, 2010).
The energy price is assumed:

- at peak hours 67 € / MWh
- off-peak hours 46 €/ MWh.

The above values were estimated by the average Marginal System Price3 for the year 2011 in the respective daily periods (peak and non-peak hours).

Furthermore, as the study focused on the benefits of the large hydroelectric plants in the RB Aliakmonas, it should be underlined that electricity production from large hydro does not entail CO_2 emissions. Consequently, if that large hydro were not present, PPC would be obliged to produce electricity from its existing lignite fire power plants, which emit CO2 and this can be considered as a direct environmental benefit (Ειδική Γραμματεία Υδάτων, 2014b).

The methodology used to calculate the economic value of the environmental benefit was based on the assumption that the production of energy from large hydro does not emit any amount of CO_2. Alternatively, this energy would be generated by the existing lignite power plants of PPC. However, the production of energy from those plants implies CO_2 emissions for which PPC is theoretically obliged to purchase pollution rights. In other words, the

[3] The Marginal System Price is the price at which the electricity market is cleared and is the price is paid off to all those who feed energy into the System and are paid by all those who request energy from the System. In particular, the Marginal System Price is shaped by the combination of the price and quantity bids that each day of the available power generation units and the hourly electricity demand, which is formed on a daily basis by consumers. It should be noted that this was the only existing electricity market price, based on the Day- Ahead Schedule Market.
According to the basic principles of microeconomic theory, it can be said that the production units are ranked according to their bids in ascending order, starting from the lowest bid price for a certain amount of energy and ending at the highest bid.
At the point where the amounts of energy offered serve the requested load, the Limit Value of the System is also determined. In essence, the System Limit Value coincides with the offer of the last unit that needs to work to meet demand (Source: http://www.rae.gr/site/categories_new/electricity/market/wholesale/price.csp).

environmental benefit of producing energy from large hydro is equal to the cost of purchasing (or holding) pollution rights to produce an equivalent amount of energy from lignite power plants (Ειδική Γραμματεία Υδάτων, 2014b).

The environmental benefit assessment was based on the following data:

- The average price of 1 tn CO_2 (right to pollute) for 2011 in both the primary and secondary market of the EU ETS (spot market market EUAs) is estimated at € 13 / tn CO_2 (CDC Climat Research, 2012).
- One lignite unit releases 1.3 tn CO_2 / MWh (TEE, 2012; Tourkolias, 2009).

The estimated total value of benefits is presented in Table 6-46.

Table 6-45: Total value of benefits of PPC's activities. Source: Ειδική Γραμματεία Υδάτων, 2014b.

Large Hydro	Electricity Production (€)	Environmental Benefit (€)	Total Value (€)
Polyfytos	27,781,557 €	6,667,440 €	34,448,997 €
Ilarionas	24,139,144 €	5,793,278 €	29,932,423 €
Sfikia	24,700.496 €	5,928,000 €	30,628,496 €
Asomata	8,450.169 €	2,028,000 €	10,478,169 €
Ag. Varvara	292,505 €	70,200 €	362,705 €
Total	**85,363,871 €**	**20,486,918 €**	**105,850,790 €**

The total estimated value of benefits related to PPC's activities in the WD09 can be seen as equal to the value of the ecosystem service (water for electricity use). In contrast with the estimation of the previous provisioning services, the estimation of PPC's activities related to water should be based on the benefits the operation of large hydro creates, as in this case, there is also a competitive energy carrier (lignite fore power plants), which should also be taken into consideration. This indirect "opportunity cost" is incorporated in the environmental benefit. Consequently, the calculation of the value of benefits reflects in a more comprehensive manner the value of the provisioning service (water for electricity use) in the specific WD.

One could note that this estimation is only a primary assessment of the value of the specific ecosystem service as further parameters can be included in that equation. Health benefits such as the provision of clean water due to the electricity production by large hydro and the avoidance of diseases and other detrimental effects to the health of the residents in the area such as asthma could also be included. Nevertheless, this needs an interdisciplinary and more comprehensive analysis, which is beyond the scope of this thesis.

6.14 Discussion

This chapter was dedicated to the estimation of the value of ecosystem services in specific geographic areas. More specifically, the value of three ecosystem services was estimated. These were the following:

- Provisioning service (freshwater provision)

- Provisioning service (provision of agricultural water)
- Provisioning service (water for electricity production)

The Integrated River Basin Management Plans in the Water Districts of Central and Western Macedonia (Ειδική Γραμματεία Υδάτων, 2014a; 2014b) were the main source for the calculation of the value of all three services. The methodology employed in both Management Plans was followed for the estimation of the three provisioning services.

Freshwater provision and water for agricultural use were treated jointly, as they were regarded as competitive and major uses in both WDs. In both cases, the financial, environmental and resource cost was calculated and was therefore treated as equal to the value of both ecosystem services.

A slightly different approach was employed for the use of water for electricity production. Principally, the financial and resource cost only of large hydroelectric plants was calculated. However, the benefits embedded by the use of large hydroelectric plants were additionally calculated and the value of those benefits could better reflect the value of water for electricity use. How these benefits correspond effectively to the value of water for electricity production as an ecosystem service will be explained below.

The concept formulated by Koundouri et al. (2016) formed the theoretical basis for the analysis and estimation of ecosystem services value, especially for the first two provisioning services. Based on that, it was assumed that the value of the provisioning services of freshwater provision and provision of agricultural water is seen as equal to the total value/ cost of water as it was estimated in the Integrated River Basin Management Plans. Nevertheless, there was a serious omission and deviation to the methodology proposed by Koundouri et al. (2016), as the economic assessment of potential measures for sustainable water management was deliberately not taken into consideration.

The author was member of the research team responsible for carrying out the economic analysis of water uses in both WDs (Ειδική Γραμματεία Υδάτων, 2014a; 2014b), which was part of the Integrated River Basin Management Plans for both WDs (Ειδική Γραμματεία Υδάτων, 2014e; 2014f). Main research activity was the estimation of cost recovery ratio for the major water uses in the WDs. Based on the methodology proposed by WATECO (2002), not only the financial cost should be calculated. Both environmental cost and resource cost are crucial cost categories that should be estimated and can define the so-called Total Economic Value of Water (Kumar et al., 2009).

After extensive discussions of stakeholders and experts on that field, the methodology based on which all three cost categories will be estimated was defined. If one looks carefully at the methodology for the calculation of environmental cost for both provisioning services, it can be noted that future projects ensuring the sustainable water management in both WDs are included in the calculation of environmental cost. Such projects were also included in the Integrated River Basin Management Plans (Ειδική Γραμματεία Υδάτων, 2014e; 2014f). In other words, environmental cost was especially in the case of freshwater provision equal to the realisation of future projects that are directly linked to the sustainable water management.

The calculation of resource cost is calculated correspondingly and it refers to foregone benefits that are mainly due to over extraction of groundwater, thus creating an additional cost that will burden water users in the future, due to the expected lack of water reserves for the satisfying the needs/ demand of all water uses. The approach used for the use lead to conservative estimation of those future cost and could also be indirectly seen as an implicit cost, which should be allocated to the respective water uses and should lead water uses to conform to a more sustainable water management approach (Bithas et al., 2014).

Consequently, potential measures for sustainable water management as stipulated in Koundouri et al. (2016) have already been included in the estimation of value of water in both WDs. Therefore, there was no need in adding those measures as both environmental and resource cost estimation took into consideration future projects and measures with which the sustainable management of water resources in the RBs of the WDs can be achieved. In other words, the “gap” between initial and desired water status as formulated in the WFD was monetized and integrated in the total economic value of water. Theoretically, the adding up of potential measures and projects to the economic analysis that was already carried out could be regarded as “double counting”, thus over estimating the overall value of water in those WDs. This is a serious but unfortunately a common pitfall in estimating the value of environmental goods such as water and should be avoided (Kumar et al., 2009). In the case of the economic analysis in WD10 and WD09, this “double counting” did not take place, but it was important to clearly and adequately justify the omission of that calculation and the deviation of the methodological framework proposed by Koundouri et al. (2016).

Another remark has to do with differentiation with the estimation of the first two provisioning services (freshwater provision and provision of agricultural water) and the third provisioning service (water for electricity use). As described above, the framework employed by Koundouri et al. (2016) was used for the estimation of the first water related ecosystem services. Based on that, water value was based on the sum of three cost categories. However, for the service “water for electricity use” an alternative approach was followed, despite the fact that these cost categories were also calculated. The reason behind this is linked with the nature of water and energy as goods.

On the one hand, water is both a depletable and renewable source. This depends on the source of water i.e. surface water or groundwater. While surface water is a renewable supply, whose supply is contingent on weather conditions, groundwater is also renewed by percolation of rain or melted snow, but most was accumulated over geologic time and, because of its location, cannot be recharged once it is depleted (Gleick, 2000). Additionally, in relation to surface water its allocation includes distributing a fixed renewable supply among competing users, while for groundwater withdrawing water now does affect the resources available to future generations. Therefore, the allocation over time is a crucial aspect (Tietenberg and Lewis, 2016).

Based on that, water has unique features as an environmental good. Firstly, there is an hierarchy concerning the sources of withdrawal based on cost, demand and availability. In other words, surface water is primarily withdrawn, while groundwater remains the second best option, as it is more less cost- effective but it can be the sole option where there is no surface water. Furthermore, there are competitive water uses, as it was described in previous chapters. Nevertheless, there is no production of water, but one speaks about water treatment, maintaining water quality standards and attaining an efficient and sustainable water allocation and distribution (Tietenberg and Lewis, 2016). With the exception of desalinisation, there is no production unit for water under the current state-of-the-art technology. The quality issue makes water difficult to "transfer" water in long distances, so water must be allocated in a constrained geographical region (Hardberger, 2013).

On the other hand, energy is more "flexible" source. There are competitive electricity production sources such as oil, gas, photovoltaic, wind and surely water. All these can produce the good "electricity". Furthermore, electricity can be transferred to long distances without any effects to its quality. Quality is not an issue per se i.e. there is no electricity of lower quality that cannot be consumed. However, the "quality" is directly linked with the source of production. Consequently, there is clean energy that comes from renewable resources such sun, water, biomass and water (WWF Ελλάδα, 2017). Other electricity production sources such as oil, coal and gas entail the emission of CO_2, which are harmful to the environment, pollute the atmosphere and contribute to the greenhouse effect and to climate change. In microeconomic theory, those effects are defined as external and goal of environmental policy is to internalise those effects, so as to reflect the real cost of electricity production (Μπίθας, 2011).

Therefore, as there are no competitive water production, one can look only at the allocation of water between competitive water uses and how these affect the sustainable water management. So as to evaluate water related ecosystem services such as freshwater provision and irrigation water, the cost of supplying water to those uses should be taken into consideration, at least at a first stage (Grizzetti et al., 2016). Due to the fact that the categories of ecosystem services are thoroughly defined and focus on very specific parameters (effect on human well-being), estimating the value those provisioning services can equal to the total cost of providing those services.

Apart from that, the provisioning service "water for electricity use" has other features. Water is here used as an input for the production of a good i.e. electricity that affects human well-being. In parallel, there also other inputs that produce the same good. In our case in WD09, the competitive electricity production source are lignite fired power plants. However, these entail CO_2 emissions, an external effect that should be taken into consideration. In contrast, large hydro is a cleaner source of energy as there are no CO_2

emissions involved in the production process. As the water related ecosystem service is examined in the analysis and there is no comparative analysis of electricity production sources, it should be a serious omission, if the environmental benefits of producing electricity by large hydroelectric plants is not taken into account. By looking into only the cost side of large hydro and consider it equal to the value of the provisioning ecosystem service can be regarded as deficient. In that case, a more holistic approach was needed, so as the additional positive external effects can be integrated into the value of the specific ecosystem service. Ergo, the value of the provisioning service "water for electricity use" was regarded equal to the benefits the electricity production by large hydro i.e. revenues by selling the generated electricity and the positive environmental benefits by producing clean energy.

Finally, there is also one last remark concerning the valuation of water related ecosystem services with the assistance of the WFD. Surely, the focus of WFD is different than that of ecosystem services valuation. More specifically, economic analysis under the framework of WFD focuses ultimately on estimating the cost recovery ratio of different water uses (WATECO, 2002). This will serve as the basis so as water pricing principles based on the full cost recovery principle. Despite the fact that there are conceptual frameworks that use WFD as a tool for evaluating water related ecosystem services (Bastian et al., 2012a; COWI, 2014; Wallis et al., 2011) there is a pure ontological question concerning the need for ecosystem services valuation. Surely, there are concerns as to how this valuation can be practically employed. WFD has set clear goals on that field, but scholars have disagreed on that matter. Kallis et al. (2013) engaged with the question "to value or not to value?", reformulating the question as "when and how to value with money?" and "under what conditions?". As a consequence, four criteria for an economic valuation were formulated (Kallis et al., 2013):

- environmental improvement;
- distributive justice and equality;
- maintenance of plural value-articulating institutions;
- confronting commodification under neo-liberalism.

Based on those criteria, both full cost pricing under the WFD and Payments for Ecosystems Services (PES) Schemes do not fulfil all four criteria and they are therefore their economic valuation should not be carried out. However, there is room for improvement as economic valuation can be calibrated and adapted to as to conform to all four criteria (Kallis et al., 2013).

Thus, it can be assumed that economic valuation and more specifically economic assessment of ecosystem services could not be a priori rejected. However, one should be careful, when to use this economic valuation as a means to a certain end.

More generally, economic valuation of ecosystem services and therefore environmental prosperity is a tool for environmental awareness. Although the contribution of environmental well-being to overall prosperity is perceived by society, the lack of valuation can undermine this contribution. Apart from any positive psychological impact, non-recognition of the essential dimensions of environmental well-being leads to direct and indirect environmental degradation. In this way, the assessment of ecosystem services in economic terms gives above all an order of magnitude for the relative magnitude of environmental prosperity, highlights the value of environmental protection and, by extension, environmental policy and should be an instrument of environmental awareness , information and education (Τράπεζα Πειραιώς, 2017).

The next step after awareness raising is to carefully draw the principles and goals of environmental policy, where economic valuation will serve as the theoretical foundation for introducing a new water pricing policy or new environmental fees and taxes. In any case, economic valuation can form the foundation, based on which new policies can be designed and implemented and could be adapted to conform to any policy goals.

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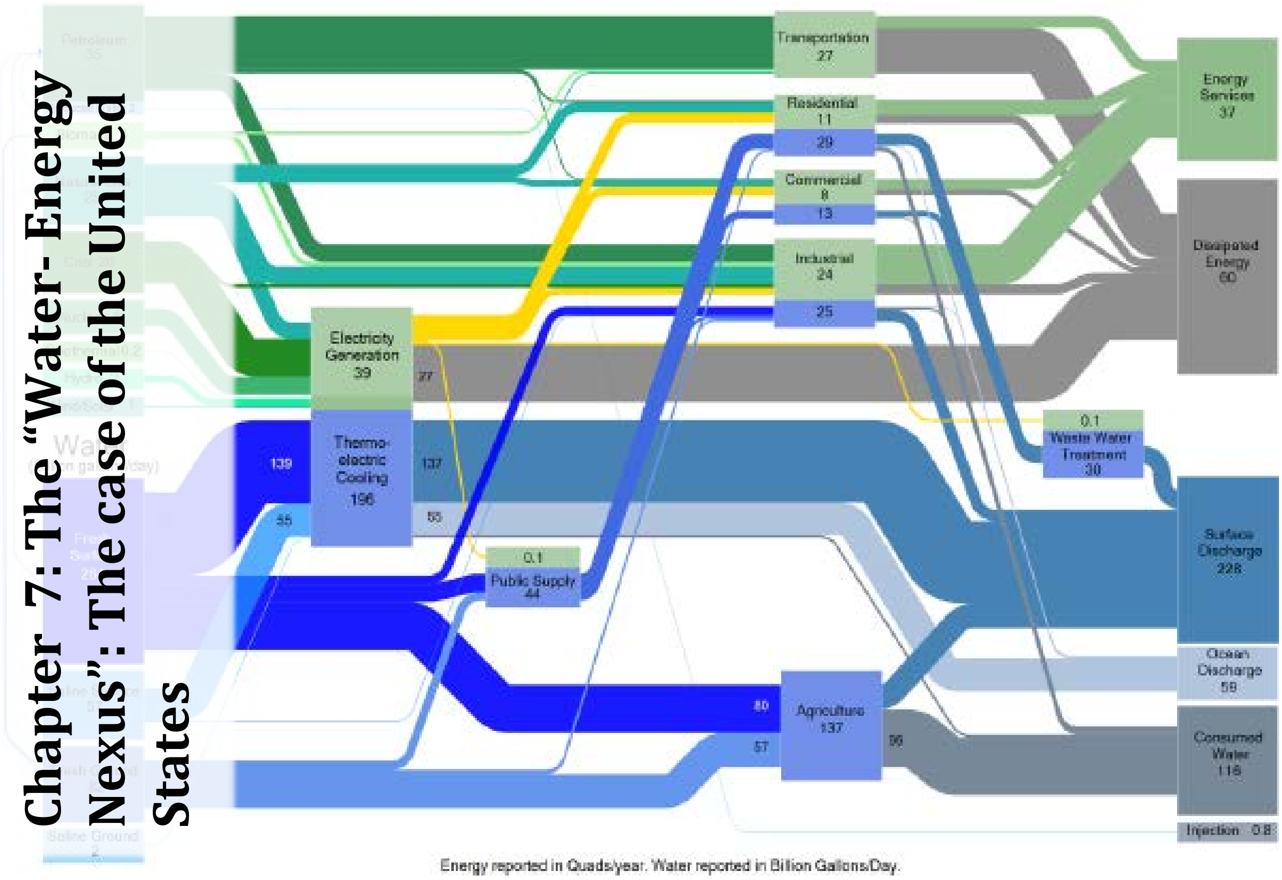
Chapter 7: The "Water- Energy Nexus": The case of the United States



Energy reported in Quads/year. Water reported in Billion Gallons/Day.

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7 Water-energy nexus in the United States

This chapter is basically focused on the description of the water- energy nexus paradigm. Water- energy nexus was firstly described by Peter Gleick (1994), as water is used for energy production, while energy is also employed for many aspects of water, such as production and treatment.

The main part of the chapter is dedicated to a thorough analysis of water-energy nexus and the multi-faceted aspects for that relationship. In no case is this paradigm constrained to a small number of categories, but it is very ample. Focus of the analysis will be the United States of America (U.S.A.), where the concept has been examined in detail. Apart from that, U.S. is a country, which possess many distinct features and many regional particularities that render this concept extremely important and in many case region and case specific. More specifically, two basic categories will be investigated: water for energy and energy for water.

Furthermore, an aspect of the energy-water nexus will be described. This concerns water desalination, which is defined as the treatment of seawater and brackish water for its conversion to freshwater. Despite the fact, that water desalination has currently a very marginal role in water-energy nexus, it is expected that it will be of emerging importance in the near future, as many regions in the US and in the World will be faced with water-shortage, due to water stress and exhaustion of freshwater sources that is further amplified by climate change and demographic parameters.

This chapter aims at presenting a more extensive view of the water-energy nexus in the US. The main question of the chapter is basically how water-energy nexus can be defined and how this can be described. Furthermore, can this paradigm assist in designing water and energy efficient policies that can secure the sustainability of water resources on the one hand and the efficient and clean production of energy on the other hand? Finally, are there any lessons learnt for US and other countries beads on this nexus?

Chapter 7: The “Water- Energy Nexus”: The case of the United States

7.1 Water-energy nexus: a brief introduction

Water- energy nexus was a paradigm first employed by Peter Gleick (1994). For the first time, Gleick investigated the correlation between water and energy. As both are considered as very crucial resources for the well-being and subsistence of human being, this link was not thoroughly examined until then. Gleick begins from the simple assumption that energy is used to clean and transport freshwater and water is consumed so as energy can produced (Gleick, 1994). Therefore, one can make the hypothesis that both sources are “intricately connected”. Despite the fact that the link was visible for many centuries now, this was not studied in detail due to the fact that both resources were considered abundant. However, new parameters have entered this link such as environmental pollution, lack of freshwater sources, climate change, influencing these correlations that have caused conflicts over energy resources and an emerging water crisis. Consequently, Gleick employed a full-scale life cycle analysis of water and energy resources to explicate and quantify the water intensity of energy resource development from extraction through power generation, as well as the energy intensity of the water sector from extraction through conveyance, treatment, distribution and end use.

The chapter will investigate the different aspects of this water- energy nexus. This presentation will unveil the multi-faceted interlinkage between these two sources. Every aspect of the nexus will be investigated, with a specific focus on the United States of America (USA.), where this interdependence has been thoroughly studied. Apart from that presentation, a more detailed analysis will be dedicated to one marginal but very crucial aspect of water- energy nexus, water desalination. Based on the fact that freshwater resources are not abundant anymore, water desalination can prove as a valuable technology concept that will ensure water supply in water stressed areas.

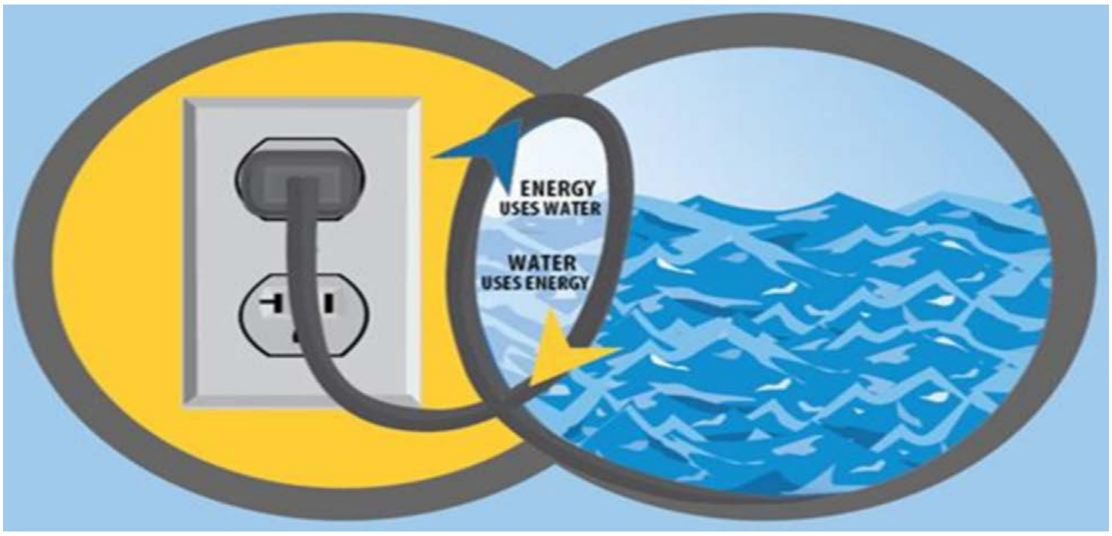

Figure 7-1: Interdependence between water and energy. Source: Hamiche Ait et al., 2016.

At first the energy for water side will be analysed, while the section on water for energy will follow.

7.2 Water- Energy Nexus: Energy for Water

On the one side of the water energy nexus lays the energy use in the water sector, i.e. the energy embedded in the water and wastewater sector. The research will be based on the Gleick (1994) and Wilkinson (2000) model on the water life cycle approach. Consequently, the following aspects/ categories will be analysed (Gleick, 2000; Cooley and Wilkinson, 2012):

- Water extraction
- Water conveyance
- Water treatment and distribution
- Wastewater treatment

Although four main categories are defined, all four contain major subcategories and further implication that render their analysis even more complicated, as it is shown in Figure 7-2 below.

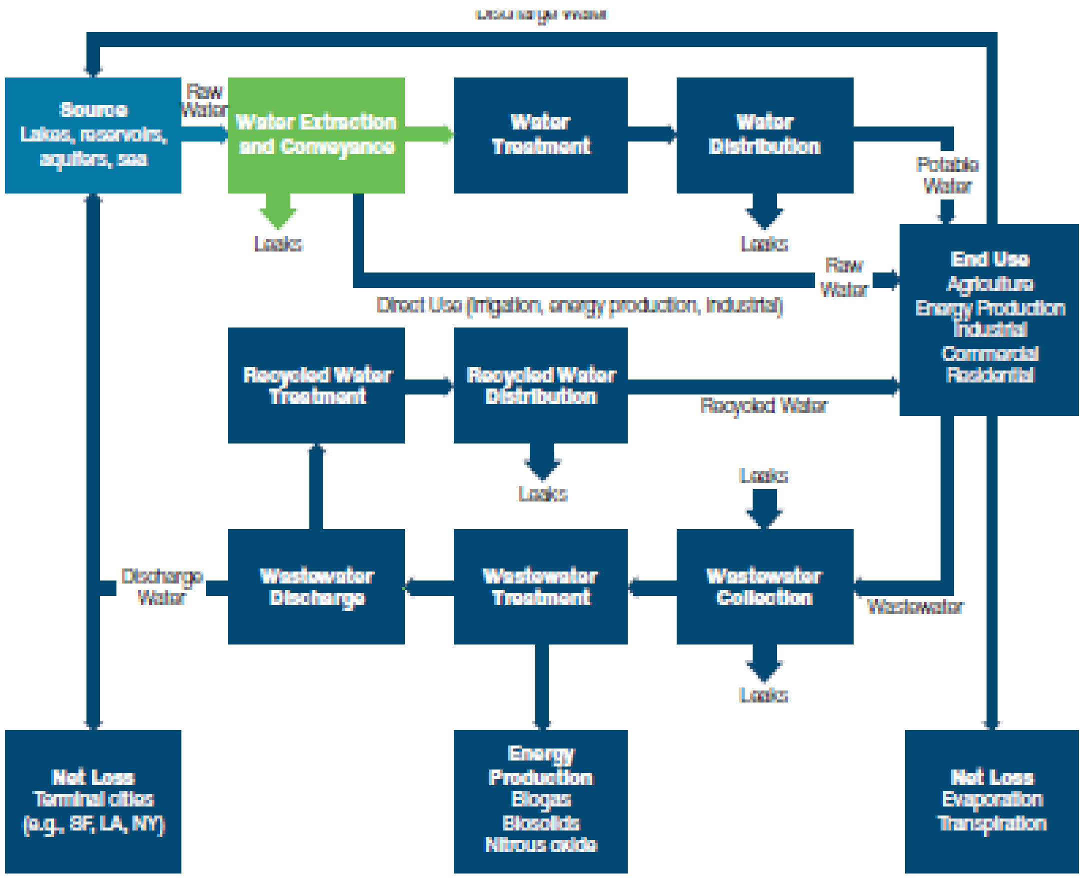

Figure 7-2: Water flowchart- Energy for Water. Source: Water in the West, 2013.

7.2.1 Water extraction

Water extraction concerns basically the places where freshwater supply is located. Therefore, the two basic sources of freshwater supply are surface water and ground water (Water in the West, 2013). Additionally, a third source of water extraction, i.e. water desalination will be described.

In general, more than three-quarters of the United States freshwater supply stems from rivers, lakes and streams, which collect rainfall and snowmelt (U.S. GS, 2009), even though freshwater sources can be highly variable. Additionally, groundwater aquifers provide about 22% of U.S. freshwater and in some case up to 30 % (California) (Wolff et al., 2004). More specifically, total freshwater and saline-water withdrawals were estimated to be 355,000 million gallons per day (Mgal/d), or 397,000 thousand acre-feet per year (acre-ft/yr). Freshwater withdrawals of 306,000 Mgal/d (86 %), and saline-water withdrawals made up the remaining 48,300 Mgal/d (14%). Most saline-water withdrawals were seawater and brackish coastal water used for thermoelectric power. Total surface-water withdrawals were estimated to be 275,000 Mgal/d (78%). About 84 % (230,000 Mgal/d) of total surface-water withdrawals were freshwater. Total groundwater withdrawals were 79,300 Mgal/d, of which 96% (76,000 Mgal/d) was freshwater (USGS, 2014).

Water supplies also tend to vary widely according to season. While desalination is a fairly insubstantial contribution to water supply nationally, it is a source that should be taken into consideration and, in a few regions, is amply employed by communities around the country (Wolff et al., 2004).

7.2.1.1 Surface Water

In total, 270,000 million gallons[4] per day (Mgal/d) of surface freshwater and 59,000 million of surface seawater are withdrawn in the U.S. (US GS, 2009). As of 2014, total surface-water withdrawals amounted to 275,000 Mgal/d, from which 230,000 Mgal/d were freshwater (USGS, 2014). Total withdrawals in 2010 were 13% less than in 2005, causing a downward shift to the basically steady trend since 1985 (USGS, 2014). Primarily, little to no energy is needed so as to be extracted (Bennett et al., 2010). The majority of freshwater withdrawals go to agriculture and thermoelectric generation, while virtually all the seawater is directed to electricity generation.

Water storage and management over seasons or years ensures that surface water from lakes and rivers or from man-made drinking water reservoirs can be stored over long time periods (Water in the West, 2013). Despite their long life expectancies, important energy inputs are required for the construction. However, evaporation and seepage losses are issues that *“limit the ability of the reservoir to provide relief over severe or extended drought conditions*” (Water in the West, 2013). This is regarded as a positive feedback loop where less water in the reservoir results in more evaporation when the water is needed most. Other problems include the sedimentation of reservoirs, which reduces reservoir capacity.

[4] Gallon is equal to 3.785 l.

A further issue that needs to be discussed is water rights allocation. As water issues face different challenges in each US region, water policies and policy and legislative framework vary greatly (Kimmel and Veil, 2009). Concerning water rights for surface water extraction there are two basic governance doctrines (US DOE, 2014). The first is defined as prior appropriation, where water allocation is made on a first-come, first-serve basis and not linked to land ownership (Getches 2009). Due to relative water shortage, water rights are linked to a specific basin and many states do not allow transfers between basins. Additionally, users must prove that their rights are being exercised and put to a beneficial use. Alternative, the rights can be deemed abandoned and terminated (US DOE, 2014). The second doctrine is named riparian, known as "the common law", is entwined with land ownership. Owners of land bordering waterways have a right to use water that flows past the land for any reasonable purpose. In addition, all landowners have an equal right to use the water because no one possesses a greater right through prior use. Water rights may not be bought or sold and when water runs short, users have to —share the shortage in proportion to their rights (Kimmell and Veil 2009).

Table 7-1: Water rights legal framework in the US. Source: Gleick and Christian- Smith, 2012.

Legal Framework in the West	Western States
Pure prior appropriation	Alaska, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming
Prior appropriation, formerly riparian	Kansas, North Dakota, Oregon, South Dakota, Texas, and Washington
Mixed riparian-appropriation	California, Nebraska, and Oklahoma
Pure riparian	Louisiana, Missouri, New Hampshire, Ohio, Rhode Island, Tennessee, Vermont, and West Virginia
Regulated riparian	Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Virginia, and Wisconsin

In addition, some of the Western states employ a hybrid doctrine. These are states that initially enforced a riparian rights system and continue to recognize riparian uses even though they later adopted a prior appropriation doctrine (US DOE, 2014)

As far as groundwater extraction is concerned there is no clear overview of some predominant doctrines. There are a number of overarching doctrines that include absolute ownership, reasonable use, correlative rights, and prior appropriation (Gleick and Christian-Smith 2012). The absolute ownership doctrine does not limit the amount of groundwater withdrawn by the overlying landowner even if the withdrawal could harm existing uses. The reasonable use doctrine, in contrast, prohibits waste and confine water usage to overlying land unless it can be transported without harming other overlying owners (Goldfarb 1988).

It should be underlined that both doctrines do not take the total demand on the aquifer or the impact of groundwater overdraft into consideration. Nevertheless, there are cases where aggregate total demand is taken into consideration and this concept is implemented is several US states (Michigan, Ohio, Wisconsin, Arkansas, Florida, Nebraska, New Jersey and Missouri (Goldfarb, 1988). However, it should be underlined that such frameworks are very difficult to implement due to lack of reporting and monitoring groundwater use (US DOE, 2014).

7.2.1.2 Groundwater

There is currently little information on the exact figures of ground water extraction. In general, it is estimated that approximately 80 billion to 85 Billion gallons(Bgals) of groundwater per day are pumped (Alley, 2010; Smith et al., 2011). In contrast with surface water, further parameters should be regarded such as specific types of pumps employed, the fuel used and whether the water is treated (US DOE, 2014).

On that issue, limited information is available. Bennett et al. (2010) reported the monthly electricity requirements of groundwater pumping in California. The study reveals that energy used for groundwater is substantial, mainly during the summer months, where it exceeds the combined energy requirements of the principal water projects in the state (State Water Project, the Colorado River Aqueduct and Central Valley Project).

Additionally, the U.S. Geological Survey (USGS) estimates nationwide groundwater withdrawals in 2005 to about 80, 000 Mgal/d for freshwater and 1.51 Bgal/d for saline groundwater (USGS, 2009). As of 2014, freshwater groundwater withdrawals decreased slightly at 76,000 Mgal/d, but more saline groundwater was withdrawn (3.29 Bgal/d; USGS, 2014). In another study, Burton (1996) estimated electricity consumption for groundwater systems at about 1,800 kilowatt-hours (kWh) per million gallons (Mgal) of water for public supply systems.

Another example is the Santa Clara Valley Water District that where farmers in the San Francisco Bay Area consume about 1,000 kWh/Mgal for groundwater pumping. Wolff et al. (2004) estimate that groundwater extraction for agriculture requires 540 to 2,300 kWh/Mgal. Bennett et al. (2010a) estimate groundwater withdrawals to require 900 to 2,900 kWh/Mgal. All in all, the energy required for groundwater extraction is estimated to be 30,000 to 50,000 gigawatt-hours (GWh), or roughly 1%- 2% of total U.S. electricity production. Bennett et al. (2010) estimate that California used 7,000 GWh of electricity on groundwater extraction in 2010.

In conclusion, the amount of energy devoted to groundwater pumping depends on three crucial parameters (US DOE, 2014)

- how deep is the water resource located that needs to be pumped;
- the volume of groundwater pumped; and
- the types and characteristics of pumping devices employed.

7.2.1.3 Desalination

Saline water sources such as brackish groundwater and seawater "*can be converted into usable water supplies by reducing the contents of total dissolved solids (TDS) or salt and minerals*" (US DOE, 2014). Brackish water is a mixture of freshwater and seawater, being more saline than freshwater and less saline than seawater. In 2005, roughly 2,000 desalination plants larger than 0.3 Mgal/D were in operation, with a total capacity of 1,600 Mgal/D, thus constituting less than 0.4% of total water use in the U.S., (Carter, 2011). The energy intensity of desalted water heavily depends on the volume of the desalted water, the quality (i.e., saltiness) of the source water supply as well as the technology used (Bennett et al., 2010).

On the one hand due to the fact that brackish water has much lower TDS than ocean water, it necessitates less energy to desalt, with energy intensities ranging from 1,400 to 1,800 kWh/Mgal (Bennett et al. 2010). On the other hand, energy intensities for seawater desalination vary (California Energy Commission [CEC], 2005; Younos & Tulou, 2005; Cooley & Wilkinson, 2012; National Research Council [NRC], 2008; Bennett et al., 2010).

The technologies used for desalination can be divided into two major categories: thermal and membrane processes (US DOE, 2014):

- Reverse Osmosis (RO), where semi-permeable membranes are used to retain salts and solids and let water through.
- Nanofiltration (NF) is a membrane process very similar to reverse osmosis, but it uses lower operating pressures.
- Electrodialysis (ED) is a method, primarily for brackish water that uses membranes which are selectively permeable to ions (either cations or anions).
- Multistage-flash distillation (MSF) is a thermal process that produces high-quality freshwater with very low salt concentrations.
- Multiple-Effect Distillation (MED) that is one of the oldest and most efficient desalination methods and relies on evaporators and condensers in series.
- Vapor compression is a thermal process that is typically used for small scale seawater units and.
- Membrane distillation combines the use of both thermal distillation and membranes.

Energy is regarded as the largest single variable cost for a desalination plant. Technologies range from 1,000 kWh/Mgal to 500,000 kWh/Mgal, often making desalination the most energy-intensive water option. Additionally, there are further costs that are related to handling and disposal of brine, the concentrate and by-product coming from extracting salts and minerals from saltwater or brackish water (US DOE, 2014).

Further details on desalination will be discussed in Chapter 7.4.

7.2.2 Water Conveyance

Conveyance is defined as "*moving raw water from source to water treatment or to direct uses in agriculture, energy production. Distribution is defined as the transport of treated water to customers that require high quality water*" (e.g., residential, commercial or industrial users) (US DOE, 2014).

This stage of the water-energy nexus consists of the infrastructure, i.e. the network of pipelines, canals and pumps that transport water from its source to a specific destination. Such closed systems of infrastructure can be energy intensive or even energy producing. This depends basically on the elevation of the water source, the volume and the distance (US DOE, 2014). Surely, the water conveyance is an important parameter especially in arid regions in the West, where cities are located far from water sources and is expected to be amplified in the future, due to demographic trends (US DOE, 2014).

Southern California is a characteristic example. In that region there several large water projects that convey water. The first one the State Water Project (SWP) that pumps water more than 3,000 feet in the Tehachapi mountain range and transports water to agriculture and municipal uses (CEC, 2005). A second project, the Central Valley Project (CVP), shares the same infrastructure with the SWP and directs 90% of the water to agriculture. San Diego, the city where SWP ends up, has an energy intensity of 9,200 kWh/Mgal for imported water (end use not included; Gleick, 2008; Sanders et al., 2012), while farmers in the Central Valley receive water with an energy intensity of 1,300 to 3,100 kWh/ Mgal (Wolff at al., 2004). In addition, pumps constitute the most energy intensive part in water conveyance. For example, the process of delivering water from the San Francisco Bay-Delta to Southern California, the California State Water Project uses 2 %- 3% of all electricity consumed in the state" (Wolff et al., 2004), while conveyance and distribution consume 7.1% of California electricity requirements or nearly 17 terawatt hours (TWh) (92% of the water sector requirements) (Sanders et al., 2012).

Distribution as part of water conveyance plays also an important role, as according to CEC (2005) California's city water agencies use about 1,150 kWh/Mgal to deliver water from the treatment plant to the customers.

Especially for energy intensive conveyance and distribution systems, certain technology interventions can upgrade their energy efficiency. Installing new variable speed drives (VSD) can substantially improve pump performance by 5%- 50%, particularly when functioning at lower loads, as pumps are more efficient closer to full load (Wolff et al., 2004), while increasing the pipe diameter can also lead to the reduction of friction losses as well as pumping requirements (here peak load plays an important role) (CEC, 2005). A second option is to maximize the potential of in-conduit electricity, generated electricity from flowing water in canals, ditches or pipelines (US DOE, 2014). This potential is estimated at about 255 MW (new or retrofitted generation between 1 kW and 1 MW) with an annual production of approximately 1,100 GWh (CEC, 2005). Another option is to minimize the losses incurred due to old and damaged infrastructure through extensive monitoring and immediate damage repair, as losses are calculated at about 10% (range between 5%-50%) (US DOE, 2014).

7.2.3 Water Treatment and Distribution

Water supply treatment is the process of removing contaminants from water, making it clean enough for its desired use, most often to drinking water standards (US DOE, 2014).

90% of Americans get water from one of the 170,000 privately or publicly owned public water systems (PWS), and the remainder use private groundwater wells (EPA, 2012). Public water systems consist 11% of freshwater withdrawals in the U.S. (two-thirds from surface water and one-third from groundwater), and private systems use nearly 5 % of groundwater withdrawals (USGS, 2009). As with water conveyance, this category of water energy nexus can be energy and money intensive water treatment and distribution consume 4.9 %- 7.7 % of electricity use in California (Bennet et al., 2010).

This stage of the water- energy nexus presents an interesting and very important feature, this of environmental standards. The Safe Drinking Water Act of 1974 (SDWA) sets federal standards for drinking water treatment. The EPA’s ensuing National Primary Drinking Water Regulations more specifically define the maximum contaminant level (MCL) of more than 90 potentially harmful compounds in drinking water. However, as of 1990, more than 36 million Americans were drinking water that violated SDWA standards (NRDC, 1993), pressing US Congress to amend the SDWA in 1996 to implement additional disclosure requirements, among other changes. But it is reported that 20% of public water systems across the country still violated SDWA standards between 2004 and 2009, and few offenders faced fines or other penalties (Duhigg, 2009).

As far as surface water treatment is concerned, raw water is initially screened to remove large debris. Traditionally, water was pre-oxidized with chlorine to kill pathogens and break down organics. However, with better state of technology and knowledge of disinfection by-products (DBP), either this step is omitted or chlorine is replaced by ozone. Alum, iron salts and/or polymeric materials are added for flocculation and coagulation. Under rapid mixing and with coagulants, smaller particles agglomerate and settle faster in the sedimentation tanks. Water passes through rapid sand filters to avoid clogging and head loss. These systems are regularly backwashed to remove filtered particles and pathogens. Sludges and impurities removed from the sedimentation basins and the filter are concentrated (dewatered) and discarded. A further disinfection stage kills any remaining pathogens using ultraviolet (UV) light, ozone, chlorine or a combination of these. Usually, a disinfectant residue is required to prevent the growth of bacteria in the system. Clearwell storage allows contact time for disinfection and provides capacity to meet peak demand. The last step is the water distribution to end-users, i.e. consumers. In California water treatment represents about 83%- 85% of the electricity embedded in potable water (CEC, 2005; Bennett et al, 2010). This explains small economies of scale for water treatment plants from 1 to 100 Mgal/d. Small water facilities consume only 150 kWh/Mgal and large facilities about 80 kWh/Mgal just for treatment (Burton, 1996).

On the contrary, groundwater requires much less treatment, such as chlorinating for disinfection and removal of odour or taste are also needed (US DOE, 2014).

In relation to energy consumption, water supply treatment is estimated to consume 1,400 to 1,800 kWh per Mgal, representing 0.8 % of the US energy (Burton, 1996; EPRI, 2002; Elliot et al., 2003; CEC, 2005 and 2006; Bennett et al., 2010). Nevertheless, such estimates are too generalized and water treatment is context specific. For example, Sonoma County in California, uses approximately 2,600 kWh to pump and treat 1 million gallons of water, while the San Francisco East Bay area – which gets higher-quality water via aqueduct from the Mokelumne River – needs only 425 kWh /Mgal (CEC, 2006).

There are two ways, with which energy in water treatment can be reduced. The first one is technology oriented. It was demonstrated that wastewater utilities that energy consumption can be reduced by employing interim storage to shift processing to off-peak periods and balance processing loads among multiple plants to optimize plant efficiencies (CEC, 2006). A report for the U.S. EPA (2008) estimates that water and wastewater treatment plants can save up to 15%- 30% electricity by installing high-efficiency motors and pumps. Lastly, newer applications of existing technologies (such as reverse osmosis), as well as new technologies, may eventually lower the energy intensity of desalination (US GAO, 2011). The second option is the maintenance of green infrastructure i.e. watersheds, as a natural water treatment "plants" and can purify water (US DOE, 2014). Natural ecosystems distil and clean water without using any energy and are therefore by far the most energy-efficient "treatment" process.

Water distribution is a topic more researched. National estimates indicate public water systems use about 1,200 kWh/Mgal to deliver water to their end-users, while California water utilities, under constant pressure in the system, require 360 to 2,500 kWh/Mgal (Bennet et al., 2010). Similar to water conveyance, water distribution can achieve energy reductions through technology upgrades (replacing pumps and old iron pipelines with PVC pipelines) and the monitoring of leaks. WSO (2009) estimated that about 0.9 million acre feet (MAF) of water are lost per year in leakage about a third of this lost water, or 0.35 MAF, is economically recoverable. This corresponds to water for roughly 2 million people or 5 percent of the population of California. It is also 20% of the "20 by 2020" goal set by former Gov. Arnold Schwarzenegger, and would be responsible for 1 billion kWh in energy savings. Still, according to WSO, for every million dollars invested, there is a return of $2.8 million in savings and the creation of 22 jobs. Extrapolated to the U.S., with the caveat that California is quite unique in water and energy use, leaks could account for 5 MAF, with 2 MAF that could be recoverable, an economy of $1.7 billion per year (WSO, 2009).

7.2.4 Wastewater treatment

Wastewater treatment consists "*of a network of sewers collecting wastewater and transporting sewage from the customer to the wastewater treatment facility*" (US DOE, 2014). This consumes on average about 150 kWh/Mgal to pump water (CEC, 2005). Wastewater pumps are primarily less efficient (than water pumps) because they pump both liquids and solids (CEC, 2005). In California wastewater treatment requires about 8GW of electricity peak load, which can be decreased up to 30% thanks to increased water storage (CEC, 2005).

Concerning the connection of households with Wastewater treatment Plants (WWTPs), 21% of the 105.4 million year round occupied households used on-site wastewater treatment, this number shoots up to about 51% for seasonally occupied housing units (ICF International, 2008).

As with drinking water, wastewater treatment standards are also officially defined and concern basically the effluents of wastewater treatment process. The Clean Water Act is once again the federal legislation that governs the treatment of wastewater. The minimum level of treatment currently required is "secondary treatment," for which standards are set for biological oxygen demand (BOD) and suspended matter. Each municipality or water utility generally may opt for a suitable technology for achieving a given standard (US DOE, 2014). According to ICF International (2008) the number of facilities providing less than secondary treatment were reduced from 4,800 in 1972 to 868 in 1992, and further declined to just 47 in 2000 (ICF International, 2008). Those remaining usually have waivers from the requirement. On the contrary, nearly 5,000 plants perform advanced treatment, exceeding federal requirements to reduce concentrations of nonconventional pollutants, such as nitrogen and phosphorus (responsible for algal blooms and dead zones in the Great Lakes, the Gulf of Mexico and other places) (US DOE, 2014). Although, there is seemingly a continuous flow of investment of wastewater facilities, EPA (2010) identified $105.2 billion in needed investment in secondary and advanced wastewater treatment.

16,000 Public Owned Wastewater Treatment Plants (POTW) serve in aggregate more than 220 million Americans (EPA, 2010). A typical POTW have a two stage and in some cases three stage treatment process. The technical processes that are carried out in each stage are explained in Figure 7-3, while Table 7-2 presents unit electricity consumption for Wastewater treatment by size or plant.

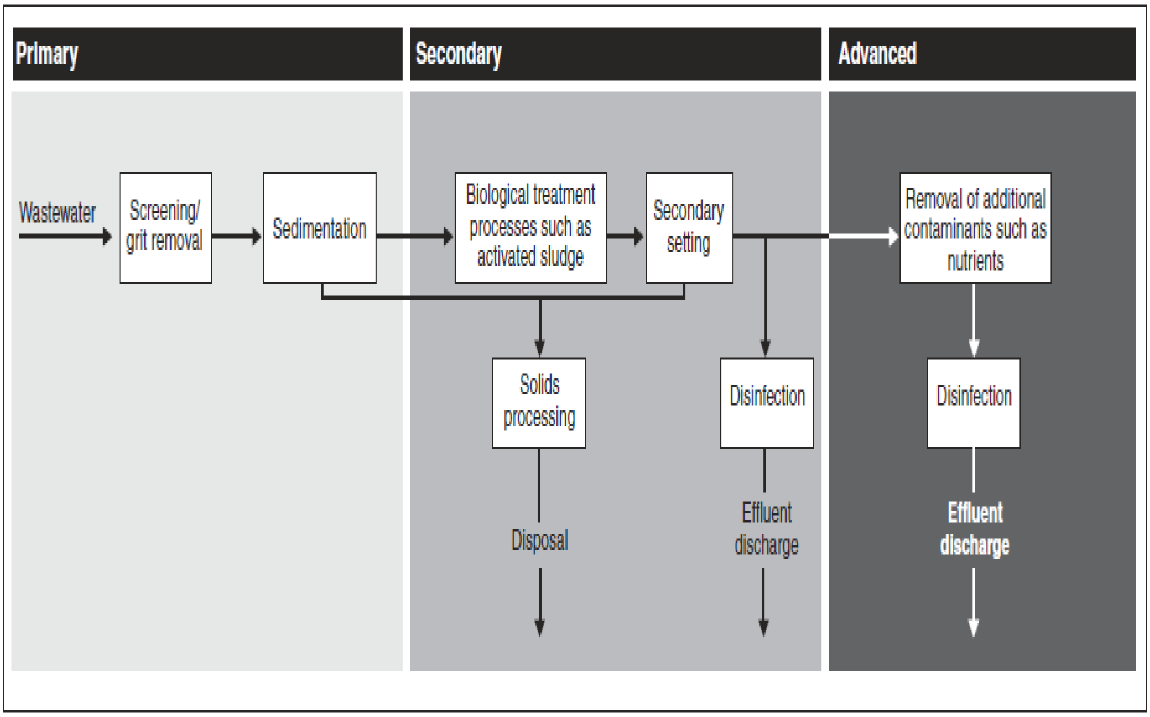

Figure 7-3: Typical Wastewater treatment process. Source: GAO, 2011.

Table 7-2 Unit Electricity Consumption for Wastewater Treatment by Size of Plant. Source EPRI, 2002.

Treatment Plant Size million gallons/day (cubic meters per day)	Unit Electricity Consumption kWh/million gallons (kWh/cubic meter)			
	Trickling Filter	Activated Sludge	Advanced Wastewater Treatment	Advanced Wastewater Treatment Nitrification
1 MM gal/day (3,785 m³/d)	1,811 (0.479)	2,236 (0.591)	2,596 (0.686)	2,951 (0.780)
5 MM gal/day (18,925 m³/d)	978 (0.258)	1,369 (0.362)	1,573 (0.416)	1,926 (0.509)
10 MM gal/day (37,850 m³/d)	852 (0.225)	1,203 (0.318)	1,408 (0.372)	1,791 (0.473)
20 MM gal/day (75,700 m³/d)	750 (0.198)	1,114 (0.294)	1,303 (0.344)	1,676 (0.443)
50 MM gal/day (189,250 m³/d)	687 (0.182)	1,051 (0.278)	1,216 (0.321)	1,588 (0.423)
100 MM gal/day (378,500 m³/d)	673 (0.177)	1,028 (0.272)	1,188 (0.314)	1,558 (0.412)

In parallel with POTWs, 23,000 privately operated treatment facilities in the U.S. associated with industrial plants and commercial operations (EPRI, 2002), with an average energy consumption of about 2,500 kWh/ million gallons (EPRI, 2002).

Energy efficiency in wastewater treatment can be partly achieved by best management practices and system optimization. Nevertheless, WWTPs have an untapped potential as during their processes by-products are products. For example bio solids from the aerobic digestion of organic matter can be used beneficially but a substantial proportion is incinerated (without electricity production) or put in landfill. Such by-products can be used as a feedstock for bioplastics or even rocket fuel (Rostkowski et al., 2012).

In addition, there is an unexploited energy potential from WWTPs. The EPA’s Combined Heat and Power Partnership (CHPP) estimates 5 Mgal/d of wastewater is equivalent to about 100 kW of electric power generation capacity and when this is combined with best management practices, they provide about half of the electricity requirements of an average facility (Wiser et al., 2010). Furthermore, estimations show that anaerobic digestion could save 600 million kWh to 5,000 million kWh annually in the U.S. (Stillwell et al., 2010).

One last topic that concerns wastewater treatment is recycled water. About 32 Bgals per day (BGD) of effluent are discharged in the U.S. (NRC, 2012; EPA, 2012). Most of this effluent or treated wastewater is returned to streams, rivers or lakes. However, about 12 BGD, or 38% of the total effluent, is discharged to an ocean or estuary. If this treated wastewater is reused, particularly the coastal discharges, available water resources will substantially increase (about 6% of total U.S. water use or 27% of public supply; NRC, 2012).

As population increases and climate change effects become apparent, reusing treated wastewater in different appropriate uses is regarded as a useful addition to diminishing freshwater reserves.

The reuse of water is not new. California has had recycled water systems since the 1920s. In the U.S., 2.5 BGD (2.8 million AFY), or roughly 7 %- 8% of treated municipal effluent is reused beneficially (EPA, 2012); however, the potential is much higher. In California for example , coastal communities discharge 3.5 million AFY of highly treated water into the Pacific Ocean. Recycled water can serve many purposes (DWR, 2009):

- It can be an additional water source (offsetting the need for additional freshwater supplies),
- a hedge against droughts,
- an environmentally friendly alternative for treatment and disposal of wastewater,
- a natural treatment through land application and
- a reduction in discharge of excess nutrients into surface waters,
- a source of nutrients for crops or landscape plants, and
- a means to enhance ecosystems such as wetlands.

The USGS and the EPA estimate that 90 % of water reuse comes from only four states (Florida, California, Texas and Arizona) (EPA, 2012). Florida publishes a comprehensive annual report of water reuse (Florida Water Reuse Program, 2012). In 2011, 722 million Mgal/D of wastewater effluent, or 0.8 million acre-feet (AF) were recycled. The majority of this water, about 58 %, was used for landscaping. In 2011 in California, recycled water accounted for 669,000 AF (US DOE, 2014). This equals to about 1% of total water needs in

California, but can be as high as 5% in Southern California (Bennett et al., 2010). Most of this water is used for agricultural irrigation, followed by landscape and golf course irrigation and nearly 20% of recycled water is used for groundwater recharge and seawater intrusion barriers. (US DOE, 2014).

Based on the above mentioned data, it can be assumed that water re-use is directed to non-potable. However, it should be noted that re-used water can be used as potable water, as in Singapore and Namibia but potable use is until now not allowed in the US due to health consideration (US DOE, 2014).

The energy intensity of recycled water depends primarily on the quality of the inflow (wastewater) and on the end use of this water. Agriculture needs for example water with low total dissolved solids (TDS) and a high nutrient content. Energy intensity of recycled water in California was estimated at 1,130 kWh/AF or 3,460 kWh/Mgal (Bennett et al., 2010). Furthermore, the increased use of recycled water displaces or avoids the marginal water supplies, which are the most expensive, often the one with the highest energy intensity. For a typical U.S. utility, recycled water is deemed preferable to desalination and comparable to importation in terms of energy. The U.S. EPA estimates that the net energy savings of recycled water are high, at 3,000 to 5,000 kWh/Mgal (EPA, 2012). And the estimated net energy savings could range from 0.7 to 1 TWh/year, or 3,000 to 5,000 kWh/Mgal. Stillwell et al. (2011) also estimate that the water re-use saves 1,400 to 1,800 kWh/Mgal needed implying that California could be saving about 300 GWh of electrical energy annually.

Finally, a brief overview of electricity consumption in the water sector, i.e. energy for water is presented in Table 7-3.

Table 7-3: Water Sector Electricity Use in California in 2001, GWh. Source: US DOE, 2014; CEC, 2005; Bennett et al., 2010.

Segment of the Water Use Cycle	CEC Study 2005	CEC Study 2006	Bennett et. al. 2010
Supply	10,742	10,371	15,786/172
Conveyance			
Water treatment			312
Water distribution			1,000
Wastewater treatment	2,012	2,012	2,012
Total Water Sector Electricity Use	12,754	12,383	18,282
% of Total Statewide Electricity Requirements	5.1%	4.9%	7.7%

7.3 Water for Energy

The other side of the water-energy nexus is concerned with the withdrawal and consumption of water for the production of electricity. Consequently, the following sources of energy will be described (US DOE, 2014):

- Coal
- Natural Gas
- Uranium
- Thermoelectric generation
- Oil
- Biofuels

As thermoelectric generation include almost all sources of energy such as coal, natural gas and nuclear power, the respective chapters will focus on extraction, processing, storage and transportation.

7.3.1 Coal

Coal still plays an important role in US energy mix, as it represents 21% of the U.S. primary energy consumption and 45% of the electricity generation in 2011 (EIA, 2012). U.S. coal is primarily produced in three regions: Appalachia, the interior and the West and the primary use of coal is electricity generation, which withdraws large amounts of water every year for cooling. Water withdrawal and consumption along with the associated pollution from the mining, processing and transportation of coal are three important issues caused by this source of energy. Such issues need more careful attention due to fact that coal production is projected to rise by 50% by 2026 (EIA, 2006).

Water withdrawal (de-watering) occurs from mining, and water consumption is needed for both mining and the reclamation of the mined land. Both underground (30 % of U.S. production) and surface mining (70 %) require water to cool and lubricate equipment and manage dust (EIA, 2011a). Gleick (1994) estimated that water consumption in underground coal mining for Appalachian coal with high sulphur content ranges from 0.8 to 5.6 gal/Million Metric British Thermal Units (MMBTU). However, surface mining for Western coal with low sulphur content usually requires less water (0.6 -1.4 gal/MMBTU). More recent work by Groubert (2012) for Texas coal calculates water consumption at 16.1 gal/MMBTU (including dewatering) or 1.6 gal/MMBTU (excluding dewatering). Water use estimates depend on the mine, the geology, the depth and width of the coal seam and the energy content of the coal. Additionally, the definition of "use" or "consumption" is defined is important.

The major water-related issue of coal mining is not the quantity of the used water, but the discharge of pollutants affecting local water quality. The Clean Water Act for example identifies four major pollutants that are regulated in discharge water from strip or underground mines: pH, iron, manganese and suspended solids. Apart from that, Allen et al. (2011) estimate that the "overburden"-to-coal ratio (overburden are the mine tailings resulted from the excavated material, upsoil and rocks) ranges from 5:1 to 27:1. In most cases, this overburden is used to fill the hole left by surface mining operations (with the notable exception of mountaintop removal). Further studies also show elevated levels of arsenic in drinking water are typically found in coal mining areas (Epstein et al., 2011). Additionally, mountaintop mining or mountaintop removal (MTR) in Appalachia is a form of surface coal mining that alters landforms (EPA, 2005) and 1.4 million acres and filling 2,000 miles of streams are affected in the states of Kentucky, Virginia, West Virginia and Tennessee (Epstein, 2011). Coal mining can have negative effects on groundwater quality (Wolkersdorfer, 2008), as groundwater can become contaminated, particularly in open-pit mining, where the coal beds are exposed. Groundwater pollution can occur both directly and indirectly (Epstein et al. 2011):

- Direct degradation comes from contaminated drainage and rainfall infiltration,
- Indirect degradation could result from blasting that creates new rock fractures. Underground mining can affect overlaying aquifers due to land subsidence.

As far as processing is concerned, coal needs to be washed to reduce sulphur content (pursuant to the Clean Air Act), reduce the amount of ash produced and increase the heat content of the coal by removing impurities (US DOE, 2014). Water requirements for washing are rather high (1 to 2 gal/MMBTU) (Gleick, 1994).

All in all, Mielke et al. (2010) estimated U.S. water consumption for coal extraction (mining and processing) at 185 Mgal/D, equal to water needs for a city like Dallas, or about 1.2 million people, since the U.S. average is 150 gallons per person per day. Chan et al. (2006) estimate the freshwater withdrawals to range from 86 to 235 Mgal/d (3 percent to 13 percent of freshwater withdrawals from the mining sector, which accounts for 2 billion gallons per day). Despite the fact that the total water withdrawals related to coal mining are relatively small when taken as a whole compared to sectors like agriculture, it appears that local and regional consumption may be acute in some cases. Finally, coal mining industry represents about 0.3% of the total industrial energy use in 1997, or 103.1 x 1012 BTU. This means that the energy intensity of coal mining is approximately 0.5 % of the extracted energy (US DOE, 2002).

7.3.2 Natural Gas

Natural gas constitutes the fastest-growing source of energy in the United States and throughout many parts of the world. The water intensity of natural gas is relatively low compared to the other energy sources and just as coal, water issues are linked to water quality, and more specifically to degradation of potable water resource (US DOE, 2014). U.S. belongs to the world’s largest producers and consumers of natural gas (BP, 2011), accounting for one-quarter of U.S. energy use and electricity generation. Due to the fact that new unconventional energy sources (e.g. shale, tight sand, coal bed methane, coal mine methane) are exploited, natural gas will continue to play a major role in the American energy mix (US DOE, 2014). The environmental impacts of unconventional natural gas most frequently cited are those on water withdrawals and water quality. On-site drilling and extraction operations require varying amounts of water (see Grubert et al., 2012), but more alarming are the water needs for single wells in unconventional reservoirs.

The EIA reports (2011b) total direct federal subsidies for the natural gas and oil industry of $2.8 billion. The U.S. Energy Information Administration (EIA) projects that the U.S. natural gas demand will grow from about 25 trillion cubic feet (TCF) today to 28 TCF in 2035, which would be a 12% increase, taking into consideration the future development of shale gas (EIA, 2012).

On the one hand, in relation to extraction of conventional natural gas requires very small amounts of water, mainly for drilling preparation (US DOE, 2014). Conventional natural gas represents 31.5% of U.S. production of natural gas and can be divided into onshore (22.5 %) and offshore (9% − mainly in the Gulf of Mexico) production. Associated natural gas, which is co-located with oil, accounts for 10 percent of U.S. production, where natural gas was regarded as an unnecessary by-product that was flared (US DOE, 2014).

On the other hand, oil shale and tight sand gas need hydraulic fracturing for their further deployment and this process requires millions of gallons per well. According to EPA (2012), 11,000 are hydraulically fractured. In general, water needed for drilling a single well can range from 60,000 gallons in the Fayetteville Shale to 1 Mgal in the Haynesville Shale (Harto, 2011). Furthermore, low-permeability natural gas resources are located in average at 6,500 feet (EIA, 2012). At these depths, the formations may underlie drinking water aquifers, which are commonly 100 to 300 feet below the surface, created problems related to water quantity. In addition, water intensity is estimated to be relatively low: 0.6 to 1.8 gal/MMBTU, compared with other sources. The range could be due to different shale plays (geologic formations), which make the water intensity of a certain well extremely site-specific (Mieke et al, 2010). However, higher energy consumption is estimated for Texas basins (1.8 to 6.7 gal/MMBTU) (Grubert et al., 2010).

Two water quality issues are apparent from the extraction of unconventional natural gas. The first issue arises from fracturing (or fracking) chemicals injected in the wells, which return to the surface, and man-made, natural compounds and salts are included in the processed water. Optimal hydraulic fracturing natural gas is assured, when proppants are injected (sand, ceramic or silicon pellets), gels, biocides and other chemicals into the wells. Fracking fluid contains 0.5 % of chemicals and 10 % of proppants by volume (Chesapeake Energy), while about 15 %- 25% of the total fracking fluid is recovered in the process (Mielke et al., 2010; Zoback et al., 2010). The flowback (with part of the original fracking fluid along with some deep groundwater) returns to the surface and is re-injected, transported off-site, or collected in lined pits and ponds and can be treated, re-used or even discharged (US DOE, 2014). One of the main concerns is that local water agencies do not the nature of the chemicals used in that process (not disclosed proprietary information) and therefore cannot opt for the optimal treatment process. Apart from that, the quantity of treated wastewater is contingent upon the potential of each source, as shale gas sites with more potential production capacity require less drilling wells (US DOE, 2014)

Furthermore, flowback water may also contain high concentrations of sodium, chloride, bromide, arsenic, barium and other heavy metals, as well as radionuclides that significantly exceed drinking-water standards (Soeder & Kappel, 2009). These high concentrations of inorganics are not usually successfully treated by municipal wastewater facilities and require much more expensive industrial-grade systems. There is already evidence on that issue, where higher salinity in some Appalachian rivers are linked to the disposal of flowback in Marcellus Shale operations (Soeder & Kappel, 2009).

A further unconventional natural gas source is coal bed methane that represents about 9% of US production (EIA, 2012). Coal bed methane extraction produces a large amount of water because the coal bed itself is an aquifer. Individual wells can produce from 1.3 to 161 gal/MMBTU in Colorado and Wyoming (US DOE, 2006). Some of the produced water can be used for drilling, but much more is produced than can be used. This water is discharged to surface streams, re-injected in underground aquifers or evaporated. Under the Safe Drinking Water Act (1974), the EPA developed minimum standards for the Underground Injection Control (UIC) Program to protect actual and potential drinking water sources from underground injection of contaminants. The EPA (U.S. EPA, 2002) concludes that the injection of hydraulic fracturing fluids into coal bed methane wells poses minimal threat to underground supplies of drinking water. However, much more research is needed on that field.

For processing, water is required for scrubbing purposes and cooling. Gleick (1994) reports that approximately two gals of water per MMBTU are consumed for gas processing. Additionally, other forms of natural gas have other processing requirements. For example, Liquefied Natural gas (LNG) water withdrawals of up to 200 Mgal/D per terminal are estimated (US DOE, 2006), while the water intensity of LNG terminals is extremely high, of about 50 gals per MMBTU (US DOE, 2014). Due to seasonal fluctuations in the natural gas use in the electricity sector, gas is stored in underground areas including depleted gas and oil fields, aquifers and salt formations (i.e., salt caverns) requires a one-time use of 500 to 600 gallons per MMBTU of storage (US DOE, 2006). Finally, transportation via pipelines is estimated at 1 gal/ MMBTU (Vielke et al., 2010).

7.3.3 Uranium

The U.S. is the world's largest producer of nuclear energy, with about 800 billion kWh in 2011 (EIA, 2011a). Principally, little water is needed to fuel nuclear power plants compared to coal or natural gas. However, nuclear power is a form of thermal electric generation and thereby requires large quantities of water at the power plant for cooling (US DOE, 2014).

Currently, there are four underground mines and four In-Situ Leaching (ISL) mines in operation in the U.S., with 90 % of the production coming from ISL (EIA, 2011a) ,while there are no open mines. ISL foresees minimal surface disturbance, as uranium is extracted from porous sandstone deposits with acidic or basic aqueous solutions and subsequently injected into the subsurface through a number of injection wells. Water requirements, mainly for dust control, ore benefaction and reclamation of surface amount to 0.5 - 1 gallon/ MMBTU (US DOE, 2006).

Due to increased uranium prices new projects are programmed to reopen in New Mexico and Utah, with estimated wastewater production of 3 million to 5 million gallons of polluted wastewater per day (US DOE, 2006). Apparently, mining process leaves behind massive stockpiles of radioactive and toxic waste rock and sand-like tailings, which can lead to leaching of radioactive (radon, uranium), toxic (selenium, arsenic, uranium and thorium) and conventional pollutants in surface water and groundwater but more research is needed on the consequences of uranium mining process, as these are currently unidentified (Gleick et al., 1994).

Uranium concentrations are very low in the ore (0.06 % - 2.71 %), Mudd and Diesendorf, 2008), and the first processing step requires separating uranium from other minerals, in uranium mills. This requires substantial amounts of water and sulfuric acid (to leach out the uranium), and the process leaves behind huge milling tailings, which are often radioactive and toxic. Conventional mills are usually located near the mines, and ISL mills are located on site. The EIA (2011a) reports that in 2010 a single uranium mill was operating in the U.S. (Utah) with a capacity of 2,000 short tons of ore per day with three others in Utah and Colorado on standby. Gleick (1994) estimated that uranium milling can consume about 3 gallons per MMBTU of product almost entirely as evaporation from tailings ponds.

As uranium has been separated from the ore into yellow cakes (63% of uranium imports are also under this form − the rest is in UF6 (EIA, 2012a), it has to be enriched in specialized facilities. All in all, processing and refining of uranium consumes 12 to 13 gallons of water per MMBTU of product for diffusion (one enrichment process) and 10 to 11 gallons per MMBTU for centrifugation (another enrichment process). The 2006 U.S. DOE report and Mielke et al. (2010) estimate 7 to 8 gallons per MMBTU for gaseous diffusion and 4 to 5 gallons per MMBTU for centrifugation. In the US there is currently one uranium conversion facility in Metropolis, Illinois and one enrichment (gaseous diffusion) at Paducah, Kentucky (Sovacool, 2008).

7.3.4 Thermoelectric generation

Thermoelectric power is responsible for 45% of total water withdrawals, 38 % of total freshwater withdrawals, and 51% of fresh surface-water withdrawals for all uses. Net power generation associated with thermoelectric-power withdrawals was 3,130,000 GWh (gigawatt-hours), or about 2 % less than in 2005. On average, 19 gals were used to produce 1 kWh of electricity in 2010, compared to almost 23 gal/ in 2005 (USGS, 2014).

Estimated 2010 thermoelectric withdrawals were 20% less than estimates for 2005. This is basically due to a number of reasons such as plant closures, use of the linked heat and water budget model data, decrease in use of coal and increase in use of natural gas, and new power plants using more water-efficient cooling technology (USGS, 2014).

The basic principle of thermoelectric generation is the employment of high-pressure steam to drive a turbine generator, which in turn produces electricity. Heat is needed to boil water into steam, and following Carnot's principles, steam at the turbine exhaust must be cooled. As mentioned above, heat can be provided by coal, natural gas and oil, nuclear energy, biomass, concentrated solar energy and geothermal energy. Most of the water withdrawals and consumption in thermoelectric power generation concern cooling. Three main technologies exist: open-loop (once-through), closed-loop (recirculation) and dry cooling. Hybrid cooling is an emerging option, combining closed-loop and dry cooling (US DOE, 2014).

Open-loop (once-through) uses water supply (from an ocean, river, lake, cooling pond or canal) to run through the system's heat exchanger to condense the low-pressure steam at the exhaust of the turbines. Water is returned to the water body about 10°C to 20°C warmer. Currently, open-loop cooling power plants represent about 31 % of U.S. generating capacity. These plants do not consume much water (i.e., they return about 99 % of the water to the source), the availability of water is critical to plant operation because of the huge demand. This makes these plants extremely vulnerable to droughts, high-temperature events and competition for water resources (US DOE, 2014).

On the contrary, closed-loop cooling relies on the high-energy requirements of water evaporation. Cooling water circulates between the condenser and a cooling tower. These cooling systems have much lower water requirements but consume much more of the withdrawn water.

Dry cooling systems are identical to closed-loop systems, however, air replaces water to cool the circulating cooling fluid, thus eliminating water withdrawal and consumption. Dry cooling is affected by ambient temperatures and humidity and have less efficient performance, particularly in hot and dry climates. The average loss of output is about 2% annually (Mielke et al., 2010), but it can reach 25 % at the peak of summer when demand is highest (U.S. DOE, 2006). Finally, hybrid cooling technology uses a combination of wet and dry cooling systems, where wet and dry cooling components can be used either separately or simultaneously (US DOE, 2014).

In relation to the allocation in different states, the largest total withdrawals for thermoelectric power occurred in Texas, where nearly all the withdrawals were from freshwater sources. Three states (Illinois, Texas, Michigan, and Alabama) accounted for more than 32 % of freshwater withdrawals for thermoelectric power. Apart from that, other three states (Florida, California, and Maryland) accounted for about 48 % of total saline withdrawals, nearly all from surface water. Finally, three other states (Hawaii, California, and Nevada) accounted for 82 % of the total saline groundwater withdrawals (USGS, 2014b).

Aggregate water-withdrawal for 1,290 thermoelectric plants in the US for 2010 was about 129 BGD of which about 3.5 BGD, or about 3 %, was consumed. The largest estimated withdrawals were realised at once-through cooling plants, (70% of annual withdrawals). Most once-through freshwater cooling systems are associated with coal-fired plants, whereas once-through saline water cooling systems are mostly at nuclear power plants. Excluding complex plants (dry and hybrid), recirculating cooling towers accounted for 60 %

of estimated consumption, consistent with the evaporative processes associated with this cooling-system technology (USGS, 2014).

EIA-reported withdrawals decreased from 198 Bgal/d in 2005 to 163 Bgal/d in 2010, an 18% decline. In both years, withdrawals at simple plants with once-through freshwater cooling dominated by coal- fired and nuclear plants accounted for just over half of total withdrawals. The largest declines in withdrawal (18.2 BGD and 9.5 BGD for freshwater and saline systems, respectively) occurred at once-through systems. Similarly, complex plants withdrawals, most of which have cooling systems consisting of once-through cooling and recirculating towers, declined 31 %. Due to the fact that once-through cooling systems withdraw larger volumes of water than cooling towers, the decline at complex plants suggests a technology shift from once-through cooling to tower- cooling systems. All in all, the decline in withdrawals at once-through saline, once-through fresh, and complex plants represents 96% of the total decrease in withdrawals, despite the fact that the number of plants in all three categories remained almost the same from 2005 to 2010 (EIA, 2006 and 2011).

Natural gas combined-cycle (NGCC) plants, (mainly recirculating towers), account for the largest increase in net generation from 2005 to 2010. Contrary to the general trend, reported withdrawals for once-through cooling for NGCC plants increased fourfold between 2005 and 2010. This proportional increase was relatively small in total magnitude (about 0.9 BGD) and may reflect use of recirculating towers in some new plants, conversion of older plants to NGCC generation without changes to existing cooling systems, or even inconsistent reporting.

EIA-reported consumption declined 1.7 BGD from 2005 to 2010, a 34% decrease. Reported consumption for plants with tower cooling systems declined for all generation types, with a 61% decrease at coal-fired plants. The reduction in consumption at cooling towers is hard to reconcile with the increased share of net electrical generation for plants with tower cooling systems (33% increase from 2005 to 2010; EIA, 2006 and 2011), and the relatively large volumes of water consumed through evaporation associated with tower cooling technology (Macknick and others, 2011). Apart from that, for once-through freshwater cooling systems reported consumption increased while net generation decreased.

In general, it can be argued that data consistency concerning thermoelectric generation remains ineffective, as it can be seen from the tables below. Apart from these studies, there are other researchers (Avery et al., 2011; Dziegielewski & Bik, 2006) that provided totally different estimates, as these were based on other assumptions while all researchers have underlined the misreporting of the other estimates. It is interesting to point out that all studies refer to data gaps and misreportings and have stressed the need for a more concise reporting (US DOE, 2014).

Table 7-4: Thermoelectric plant water withdrawals by generation and cooling-system types as reported to the U.S. Department of Energy, Energy Information Administration (EIA) for 2005 and 2010, and as modelled by the U.S. Geological Survey (USGS) for 2010.[Values may not sum to totals because of independent rounding. All withdrawal is in millions of gallons per day; NGCC, natural gas combined cycle; NA, not applicable; NR, not reported; Complex, geothermal and solar thermal plants and plants that have multiple cooling-system types, generation technologies, and/or use multiple fuels]. Source: USGS, 2014.

			Oil	Nuclear	NGCC	Gas steam	Coal	Complex	Totals
Once-through saline	EIA	2005	5,037	16,998	NR	14,652	3,843	NA	40,53
		2010	1,349	12,357	1,402	10,533	5,413	NA	31,054
	USGS	2010	659	17,019	1,213	1,209	2,363	NA	22,463
Once-through fresh	EIA	2005	998	20,638	292	9,661	71,359	NA	102,948
		2010	35	21,815	1,188	5,952	55,736	NA	84,725
	USGS	2010	21	15,405	446	2,442	49,489	NA	67,803
Recirculati ng pond	EIA	2005	NR	1,177	15	1,073	5,058	NA	7,324
		2010	NR	5,246	102	1,631	7,742	NA	14,72
	USGS	2010	NA	166	16	21	187	NA	390
Recirculati ng tower	EIA	2005	13	578	1,038	102	3,422	NA	5,153
		2010	1	1,076	643	50	1,497	NA	3,268
	USGS	2010	1	605	384	32	1,259	NA	2,283
Complex	EIA	2005	NA	NA	NA	NA	NA	42,18	42,18
		2010	NA	NA	NA	NA	NA	29,272	29,272
	USGS	2010	NA	NA	NA	NA	NA	35,753	35,753
Totals	EIA	2005	6,048	39,392	1,346	25,488	83,682	42,18	198,136
		2010	1,385	40,494	3,334	18,166	70,388	29,272	163,039
	USGS	2010	681	33,196	2,06	3,704	53,298	35,753	128,692

Table 7-5 : Thermoelectric plant water consumption by generation and cooling-system types as reported to the U.S. Department of Energy, Energy Information Administration (EIA) for 2005 and 2010, and as modelled by the U.S. Geological Survey (USGS) for 2010. [Values may not sum to totals because of independent

rounding. All consumption is in millions of gallons per day; NGCC, natural gas combined cycle; NR, not reported; NC, not calculated; NA, not applicable; Complex, geothermal and solar thermal plants and plants that have multiple cooling-system types, generation technologies, and/or use multiple fuels]. Source: USGS, 2014

			Oil	Nuclea	NGCC	Gas	Coal	Complex	Totals
Once-through saline	EIA	2005	NR	NR	NR	NR	NR	NR	NR
		2010	NR	NR	15	38	NR	NA	53
	USGS	2010	NC	NC	NC	NC	NC	NA	NC
Once-through fresh	EIA	2005	NR	219	NR	28	210	NA	456
		2010	25	236	0.3	30	288	NA	579
	USGS	2010	0.2	157	5	27	503	NA	692
Recirculating pond	EIA	2005	NR	168	7	103	183	NA	462
		2010	NR	64	0.2	3	370	NA	437
	USGS	2010	NA	166	16	21	187	NA	390
Recirculating tower	EIA	2005	12	414	600	62	2,164	NA	3,251
		2010	0.4	384	334	42	835	NA	1,596
	USGS	2010	0.8	433	268	23	867	NA	1,591
Complex	EIA	2005	NA	NA	NA	NA	NA	793	793
		2010	NA	NA	NA	NA	NA	603	603
	USGS	2010	NA	NA	NA	NA	NA	832	832
Totals	EIA	2005	12	801	606	193	2,557	793	4,962
		2010	25	684	350	113	1,493	603	3,268
	USGS	2010	1	756	288	71	1,557	832	3,505

7.3.5 Oil

U.S. is currently the world’s first consumer and third producer of oil (BP, 2011). Oil accounts for a quarter of U.S. energy use, most of which is consumed in transportation and industrial use. There currently two sources of oil: conventional and unconventional (oil sands and oil shales).

In relation to drilling and extraction, conventional oil is not very water intensive, but has grave effects on water quality (U.S. DOE, 2006). During extraction, the important volumes of produced water are the main connection between oil production and water quality (Allen et al., 2011). The major oil-producing areas in the United States are in the Gulf of Mexico region (onshore and offshore), California and Alaska. There are about 500,000 active oil wells in the US., both onshore and offshore (NRC, 2010).

Water intensity depends on heavily on local factors e.g. oil in Texas is relatively light, while the oil in California is much heavier and harder to extract. In total, 0.8 to 2.2 gallons per MMBTU required to extract oil, including water for drilling, flooding and treating (U.S. DOE, 2006; Elcock, 2010; Wu et al., 2009; Mielke et al., 2010). This is on average much more than the extraction of natural gas, coal or uranium.

Drilling is related to water quality as the fluid stemming from the process contains contaminants. This problem is aggravated, if drilling takes place offshore as it can cause a build-up of debris layers on the ocean floor dangerous for benthic (bottom-dwelling) communities. Drilling wastes may contain trace amounts of mercury, cadmium, arsenic, radionucleotides and hydrocarbons (NRC, 2010).

Next to drilling, extraction follows. Oil recovery is secured through water flooding and mechanical pumping. The large volumes of water injected for secondary recovery are associated to the high water intensity (62 gal/MMBTU) of oil extraction. Tertiary production also uses large volumes of water and is particularly energy intensive (as much as 1 unit of energy is needed for 3 units of recovered resource). This water use is entirely consumptive, although salt, brackish or recycled water may be used for some of these processes (US DOE, 2014). It should also be noted that, along with oil water is also extracted (produced). The quantity of produced water can be three times more than crude oil (Khatib and Verbeek, 2003). Currently, produced water is re-injected or reused it as part of tertiary production activities for onshore wells (98 % of produced water; Clark & Veil, 2009). However, 91% of produced water from offshore wells is discharged into the ocean (Clark & Veil, 2009). The main areas of concern in terms of environmental impacts are saltwater contamination of groundwater due to poor casing and well decommissioning procedures, as well as releases of oil and improper disposal of saline water produced with oil.

Oil sands are a mix of clay, sand, water and bitumen (a dense and extremely viscous form of petroleum). Oil shale is a type of sedimentary rock that contain kerogen, a waxy substance that liquefies when heated, producing a precursor to crude oil.

For surface mining, one of the extraction techniques for oil sands, the sands are excavated and trucked to extraction plants, to separate bitumen from the sands using hot water and chemicals. However, approximately two tons of oil sands generates one barrel of synthetic crude oil. Moreover, these waste products are usually composed of 50% - 60% water, and take more volume than the original ore, making their transport and storage more difficult. Thus, much of the used water leaves the processing plant with the waste, retained in tailings areas (Davis & Velikanov, 1979; Gleick, 1994). Canada's National Energy Board (NEB) (2006) estimates surface mining operations require 2 to 4.5 tons of water for one barrel on synthetic crude oil, or 15 to 33 gal per MMBTU. For in-situ extraction, another extraction technique, 9.4 gallons per MMBTU for SAGD (Wu et al., 2009). Concerning water intensity, for crude oil extraction from oil sands range from 10 to 50 gallons per MMBTU, although more recent averages are between 20 and 30 gallons per MMBTU, lower than the water intensity of conventional oil extraction (Gleick, 1994; NEB, 2006; Mikula et al., 2008; Wu et al., 2009; Gosselin et al., 2010; Allen et al., 2011).

Oil shale deposits are located in the Green River Formation covering parts of Utah, Colorado and Wyoming (World Energy Council, 2011). Similar techniques with oil sands are followed. Consequently, surface mining techniques of oil sands, estimates ranging between 7.2 to 38 gal/MMBTU (Gleick, 1994; Bartis, 2005; U.S. DOE, 2006). In-situ mining, also called the In-situ Conversion Process (ICP), accelerates the natural process of oil and gas maturation by a slow heating of the oil shale, requiring about 250 to 300 kWh of electricity per barrel of oil to drive the process, with water intensity amounting to 8 to 9 gallons per MMBTU (U.S. DOE, 2006).

Concerning processing and refining of oil, as transportation has a marginal role in terms of water withdrawal and consumption, an average water withdrawal demand of 80 gallons per MMBTU of crude-oil input and an average consumption of 6.4 gallons per MMBTU (Davis & Velikanov, 1979). Finally, storage requires 7 gallons of water per gallon of storage capacity, as S. stores oil in the salt caverns of the Strategic Petroleum Reserve.

7.3.6 Biofuels

Biofuel describes any fuel produced from biological materials, burned for heat or processed into alcohol or diesel fuel. It mainly refers to transportation fuels produced from food crops (e.g., corn, sorghum, sugar cane, and soybean), crops for energy (e.g., switchgrass or prairie perennials), crop residues, wood waste and by-products, and animal manure.

In the U.S., nearly all biofuel production comes from corn ethanol used as a gasoline substitute (10 % blended into gasoline in 2011), and to a lesser extent, vegetable oil and soybean for biodiesel (2 % of diesel consumption in 2011).

In relation to biofuels production, corn ethanol comes from the conversion of corn to ethanol through -milling or wet-milling. Production one bushel of corn in USDA Region 7 (North Dakota, South Dakota, Nebraska and Kansas) consumes 865 gallon of freshwater from irrigation. Producing one bushel of corn in USDA Regions 5 (Iowa, Indiana, Illinois, Ohio and Missouri) and 6 (Minnesota, Wisconsin and Michigan) requires only 19 and 38 gallons respectively, because of sufficient water from precipitation (Wu et al., 2009). These three regions produce about 90 % of U.S. corn and 95 % of corn ethanol. This is an average of 263 gallons per bushel, or 94 gallons of water per gallon of ethanol, or 1,200 gallons of water per MMBTU, just for the feedstock (US DOE, 2014). The second source of bioethanol, cellulosic ethanol, stems from forest by-products does not require much irrigation (US DOE, 2006). Furthermore, biodiesel is produced from oil-containing crops, like soybeans, or used vegetable oils. The USDA reports that water use for irrigated soy production in the U.S. varies from 0.2 acre-feet/acre for Pennsylvania to about 1.4 acre-feet/ acre for Colorado, with a national average of 0.8 acre feet of water (U.S. DOE, 2006). The average output is estimated at 42 bushels per acre, or 42 gallons of biodiesel per acre. The average water use for the production of soy is of 50,000 gallons of water per MMBTU, with a range of 14,000 to 60,000 gal/MMBTU.

For processing, refining and storage, corn ethanol water use in wet mills averages 4.7 gallons per gallon of ethanol, or 62 gallons per MMBTU, while in dry mills it is 3 gallons per gallon of ethanol, or 40 gallons per MMBTU (U.S. DOE, 2006;Wu et al., 2009). The weighted average is therefore of 42 gallons per MMBTU, although dropping rapidly. Biochemical conversion for cellulosic ethanol requires water and consumes 78 to 130 gallons of water per MMBTU, while thermochemical conversion consumes 25 to 30 gallons per MMBTU but requires much more energy (Wu et al., 2009). Biodiesel have showed that water use during processing is only 4.2 gallons per MMBTU produced (U.S. DOE, 2006). Because transportation concerns the feedstock transport to refineries, located close to the fields, by trucks no water withdrawals or consumption occur. Nevertheless, this creates a much bigger energy and carbon footprint (US DOE, 2014).

7.4 Water Desalination in the US: Costs, Challenges, Prospects and the Sustainability Issue

United States are considered one of the global leaders in the desalination sector along with Saudi Arabia and United Arab Emirates with daily production capacity 2 BGD and approximately 1.336 plants in 2013 (Ziolkowska & Reyes, 2017).

Development of desalination in the US was triggered by two contradicting factors. The first one was an increasing water demand and the second one a dramatic decrease in surface and groundwater resources (Ziolkowska & Reyes, 2017). The first water desalination plant with capacity of 3.4 MGD inaugurated in Guantanamo Bay, Cuba in the 1960's after the political implications caused by the Cuban revolution and the Cuban Missile Crisis (West Basin Municipal Water District, 2014).

In 2013, 68% of the plant capacity was produced from brackish and inland water, 23% from river water and remarkably only 4% from seawater. Source water can be considered as the most important factor influencing total cost. For example, water salinity, measured in Total Dissolved Solid (TDS) i.e. the total amount of mobile charged ions dissolved in a given volume of water, expressed in mg/L or part per million (ppm) (Ziolkowska & Reyes, 2017).

The technologies employed are presented in Table 7-6.

Table 7-6: Classification of Desalination Processes. Source: AEDyR, 2009.

Separation Mechanism	Energy	Process	Name
Water Separation	Thermal & Electrical	Evaporation	Multi Stage Flash (MSF); Multi Effect Distillation (MED); Thermal Vapor Compression (TVC); Solar Desalination

			(SD)
		Crystallisation	Freezing Formation of hydrates
		Evaporation & Filtration	Membrane Distillation
	Electrical	Evaporation	Mechanical Vapor Compression (MVC)
		Ionic Filtration	Reverse Osmosis
Salt Removal	Electrical	Ionic Migration	Electrodialysis (ED)
	Chemical	Others	Ion Exchange (IX); Solvent Extraction (SE)

As 2013, 73% of desalinated water in the US was supplied to municipalities as drinking water, 22% to the industry sector, 5% to power stations, 2% in tourist facilities and the rest 1% to agriculture and military (Ziolkowska & Reyes, 2017). Furthermore, RO supplies 88% of desalinated water, ED 8%, nanofiltration 3% and 1% electrodeionisation. Older technologies such as MSF and MED are use at a low scale with 18 MGD and 66.6 MGD of produced water (Ziolkowska & Reyes, 2017).

Before proceeding with the analysis of cost parameters for desalination in the US, a segment of the research will be dedicated to a SWOT (Strengths, Weaknesses, Opportunities and Challenges) analysis of desalination in the US. SWOT analysis is a tool, which can facilitate the comprehension of that niche of the water-energy nexus. This SWOT will focus only on crucial parameters are there are cases where opportunities and threats can site- specific.

7.4.1 Desalination in the U.S.: Strengths

Main strengths of desalination in the U.S. are the following (Ziolkowska & Reyes, 2017):

- Alternative water source for areas that are plagued by droughts and have high water demand
- High yield of produced water
- Minimises water stress and pressures on other water sources (Surface and groundwater)
- Does not depend on weather events
- Fast and flexible adjustment to technology innovations
- Reliable back-up water source as it supplies water in emergency events (up to the plant's total capacity.

Due to increasing competition, the desalination sector has been flexible when integrating to new and more efficient technological innovations. It has been proven that more precise desalination membranes increase efficiency of desalination and reduce the total desalination costs, and thus the price for desalinated water for the final consumer (Ghaffour et al., 2013; Nair and Kumar, 2013; Penate and Garcia, 2012; Zhou and Tol, 2004; Van der Bruggen, 2003).

In the face of increasing population and continuous extreme events such as droughts, desalination has been regarded as a technology that can help alleviate the identified stress on water resources. In this way, also natural habitats and environmental flows can be protected. In addition, desalination is highly effective as large plants have desalination capacities of 25-30 MGD, while they are ready for emergency situations and urgent spikes in water demand. Also, using the full production capacity of desalination plants could generate economies of size and consequently allow for lower water costs for desalinated water, whose cost is considerably high in contrast with tradition water sources (Ziolkowska & Reyes, 2017).

7.4.2 Desalination in the U.S.: Weaknesses

High production costs of desalinated water and high water rates consist basically the main weakness of desalinated water (Ziolkowska & Reyes, 2017). The prices for desalinated water are variable and on average two or three times higher than prices for water from traditional water sources (Afgan et al., 1999). In 2010, the price varied between \$0.2- 1.2/m^3 (\$0.8-4.5/kgal) for desalinated brackish groundwater and \$0.3- 3.2/m^3 (\$1.1-12.1/kgal) for desalinated seawater) (Gude et al., 2010; Karagiannis and Soldatos, 2008). However, this can also be considered as a challenge at the same time, as solutions are explored that would help decrease desalination production costs and thus make the technology a complementary option.

It should be underlined that cost feasibility of desalination is not necessarily a fair comparison because the current prices paid for conventionally treated fresh water usually do not reflect the true value of water resources. Moreover, the prices for water from conventional sources do not include the water scarcity value i.e. the opportunity- resource cost in the WFD that would otherwise increase the water rates and render desalination a competitive option.

There are basically two major cost categories: capital costs (CAPEX) and operation and maintenance (O&M) costs (OPEX; Cooley and Ajami, 2012). Capital costs refer to the financing costs of the project. These include the cost of debt, based on the interest rate of the debt incurred for the project and the cost of equity, the return paid to private equity investors to compensate for the risk they undertake by realising this investment (Cooley and Ajami, 2012). O&M costs (OPEX) are seen as the costs he ongoing costs required to operate the plant, including expenses associated with replacement membranes, chemicals for pre and post-treatment, energy to run the plant, environmental monitoring, and labor for plant operators. Labour costs are primarily fixed, e.g., they do not vary with respect to the amount of water produced. Other O&M costs, such energy and chemicals, are variable and thus change in response to the amount of water produced. Figure 7-4 presents the annual breakdown of typical seawater desalination plant (NRC, 2008).

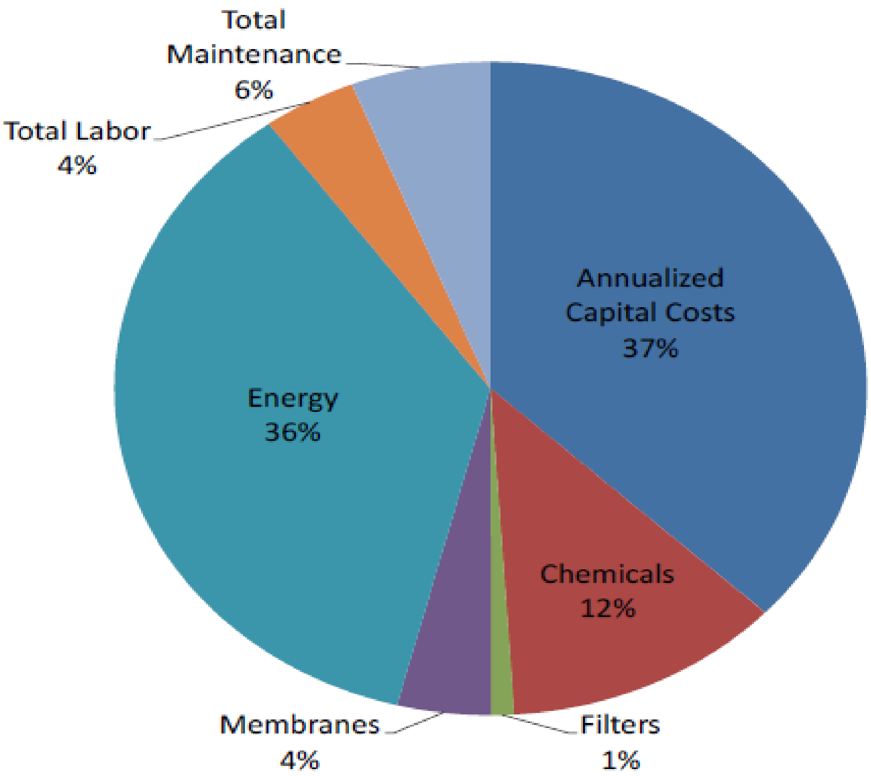

Figure 7-4: Annual breakdown of typical seawater desalination plant. Source: NRC, 2008.

NRC (2008) concludes that energy represent 38% of total annual costs. Other estimates increase the share of energy costs 46% and 73% of the total desalinated water cost, depending on the salinity levels (Mabrouk et al, 2010). In general, recent research identified a linear relationship and a very strong correlation between the energy pieces and the final water prices (Ziolkowska, 2015). Table 7-7 presents energy requirements and investment cost for desalination plants according to their technology.

Table 7-7: Energy Consumption and Average Water Cost of Large-Scale Commercial Desalination Processes. Source: Ziolkowska & Reyes, 2017.

Process	Thermal Energy	Electrical Energy	Total Energy	Investment Cost	Total Water Cost
	(kWh/m^3)	(kWh/m^3)	(kWh/m^3)	(\$/m^3/day)	(\$/m^3)
MSF	7.5-12	2.5-4	10-16	1200-1500	0.8-1.5
MED	4-7	1.5-2	5.5-9	900-2000	0.7-1.2
Seawater RO	-	3-4	3-4	900-2500	0.5-1.2
Brackish RO	-	0.5-2.5	0.5-2.5	300-120	0.2-0.4

Another critical cost component of desalination plants are brine disposal. Methods and costs of brine disposal are presented in Table 7-8.

Table 7-8: Cost Comparison of Brine Disposal Options. Source: Ziolkowska & Reyes, 2017.

Disposal Option	Cost ($/m^3)	Critical Factors
Surface water	0.03-0.3	Piping, pumping, and outfall construction
Evaporation pond	1.18-10.04	Pond size and depth, salt concentration, evaporation rate, pond liner cost
Deep Well Injection	0.33-2.64	Tubing diameter and depth, injection rate, chemical costs
Sewer	0.3-0.66	Disposal rate, salinity, sewer capacity, fees
Brine Concentrator (Zero Liquid Discharge)	0.66-26.41	Disposal rate, energy costs, salinity

Brine disposal costs can be kept low if brine is disposed back to the ocean. In the case of seawater desalination, it needs to be mentioned that the favourable location of seawater desalination plants (eliminating brine disposal costs) cannot completely make up to the energy requirements that are very high because of high water salinity, rendering brackish desalination plants are more desirable and affordable. However, due to lack of legislation, many brackish desalination plants dispose of brine directly into sewers, keeping the disposal costs very low, despite potential environmental harm created by those practices (Ziolkowska & Reyes, 2017).

Brine disposal is also related to another weakness of desalination. More specifically, brine from seawater RO plants accumulates on the sea floor in shallow coastal waters and negatively affects benthic communities, whereas in the case of brackish groundwater desalination, disposal to the sewer can negatively impact river ecosystems and increase wastewater treatment costs. Such negative impacts have been highlighted in a number of publications (Dickie, 2007; Lattemann, 2007; NRC, 2008; Cooley et al., 2013). However, more updated research is needed on that field.

One further weakness of desalination plants is that they should operate at a high capacity and require a demand market to be efficient. Nevertheless, in most cases smaller units (desalination skids) would be enough to satisfy local water needs. However, the current lease price ($700,000- 3,000,000) for production capacity between 200,000 GPD and 1 million GPD is a considerable financial barrier for a broad application of portable appliances (BenJemaa, 2009).

7.4.3 Desalination in the U.S.: Opportunities

As more than 50% of the contiguous US area has been affected by drought, with about 8% constituting extreme or exceptional drought in California, Texas, and Oklahoma in March

2015, desalination is emerging as promising method for providing water (Drought Monitor, 2015). It should be underlined that water conservation measures have a limited effect on the existing freshwater resources, because already aquifers, mainly groundwater, are under stress and close to depletion. Therefore, desalination is become viable technology option to meet urgent water demand resulting from drought as well as to provide a long-term solution (Ziolkowska & Reyes, 2017).

The abundance of water is one of the opportunities offered to the desalination sector in the US. According to USGS (2014), mineralized brackish groundwater underlies most of the country. Brackish water is defined as water with a greater TDS (1,000 and 10,000 mg/L TDS) than present in fresh water, but lower than the one observed in seawater (35,000 mg/L TDS). Brackish water is also classified as "saline" water characterized with a TDS greater than 1000 mg/L. With 95,471 miles of shore line, seawater desalination has a lot of hidden potential if exploited (Ziolkowska & Reyes, 2017).

Governmental and regional support for desalination in the form of subsidies presents one of the opportunities for a fast development of desalination. This resembles the case of renewable energy support in Germany and afterwards in the European Union. It has been confirmed that the majority of desalination projects in the US are subsidized to some degree, but their estimation is currently not possible (Cooley et al., 2006). Nowadays, subsidies for establishing new desalination plants create a boost to the development of the sector and attract private investors. As with any developing sector and market, subsidies are meant to be a short-term stimulus crucial for their uptake (Ziolkowska & Reyes, 2017).

One further interesting spill-over effect is that desalination can be regarded as an opportunity for the initiation of an extensive discussion on regional and national level on the true value of water (Ziolkowska & Reyes, 2017). Until recently, water has been considered as a free, inexhaustible resource and current water rates represent only the costs of extracting water from aquifers, water treatment costs, delivery costs to the final consumer, and administrative costs of water utility companies. As it was described above, desalinated water cost reflects its true economic value and therefore presents high cost. However, water cost from other sources such as groundwater do not incorporate the relative resource cost, as it was explained e.g. in the WFD, and does not reflect its true economic value. Such discussion can include workshops, awareness raising campaigns, establishment of water market and/ or water banks.

7.4.4 Desalination in the U.S.: Challenges

Environmental issues are basically the major challenges of desalination in the US. Firstly, with seawater intake, the risk of loss of aquatic organisms through impingement (organisms collide with intake screens) or entrainment (organisms are drawn into the plant with the source water) is highlighted (Cooley et al., 2013). Also construction of the intake infrastructure and piping could potentially disturb the seabed and cause resuspension of sediments, nutrients, or pollutants into the water column. Moreover, desalination plants could increase ambient seawater salinity in the ocean and contribute to seawater pollution through chemical additives in the desalination process such as sodium hypochlorite, ferric chloride, or aluminium chloride.

Further potential impact on marine life concerns changes in seawater temperature caused by elevated outlet water temperature from cooling processes in situations when desalination plants operate in conjunction with power plants. While most organisms can adapt to minor temperature deviations and salinity level changes, continuous exposure could cause long-lasting change in species composition. Other concerns regard dissolved oxygen, chlorine concentration, heavy metals, and unionized ammonia removed in the desalination process (Lee et al., 2008; Abdul-Wahab and Jupp, 2009).

An emerging challenge is GHG emissions as the increasing demand of desalination plants. Nevertheless, there are state programs, policies, and agencies that should be considered when developing a desalination project. In California, there are environmental review requirements, permits by the Coastal Commission, the Integrated Regional Water Management Planning process and policies of other state agencies, like the State Lands Commission, the State Water Resources Control Board, and regional standards like the California Environmental Quality Act. (Pankratz, 2012; Cooley et al., 2013).

Another operational challenge are the risks related to various factors including design and technology, financing sources, permits, construction, operation/performance, financing, markets, and policy regulations, as well as ways of mitigating those problems (Cooley and Ajami, 2012). More specifically, mothballing desalination plants takes place, if desalinated water is not needed and/or it is not competitive with current rates for water from traditional sources. It was already highlighted as a weakness that desalination plants should operate at a high capacity and require a demand market to be efficient. There are such cases in the US, where the Santa Barbara desalination plant, built in 1992 and mothballed after 2 months of operation, and the Yuma plant in Arizona mothballed 1 year after the start of its operation (Bureau of Reclamation, 2012).

All in all, primary challenge for the desalination sector in the US is lowering or stabilising final prices. On the one hand, emerging sustainability and environmental issues may rise the cost of desalinated water provision (Lior, 2017). On the other hand, the volatility of energy prices, due even a slight increase in oil/gas prices could significantly affect desalination costs and negatively impact the development of the sector (Cooley and Ajami, 2012).

Table 7-9 Operating and Desalination Plants in California, Florida and Texas in 2013. Source: Ziolkowska & Reyes, 2017.

2013	California	Florida	Texas	% of 3 States in US Total
Plants online	98	144	67	45%
Total MGD	290.3	674.7	152.8	66.3%
Technology				

RO	263.5	655	146.8	68.5 %
MED	2.9	2.1	5.9	37.6%
Users				
Municipalities	208.3	617.1	107	77.3%
Industry	41.7	23.5	39	31.2%
Power generation	21.9	10.7	4.6	53.5%

7.4.5 Desalination in the U.S.: The example of three states

This chapter will focus on three specific states: California, Florida and Texas. All three states were picked up as examples for a variety of reasons. Firstly, they have aggravating climatic conditions. California has been suffering from drought since early 2012, with 100% of the state's area affected, and almost 80% of the area plagued by extreme drought since 2014. The extreme and exceptional drought in Texas in 2011 and Competition for Water Resources 2012 affected 98% of its land area. As of March 2015, 60% of the area in Texas was affected, while only 15% can be attributed to extreme and exceptional drought. Florida was impacted by drought mainly in 2011-2013. Nevertheless, extreme drought affected only 40% of the state in the peak times during that period (Drought Monitor, 2015). This means that if climatic conditions continue as described above, water conservation measures will not be enough so as water resources are not depleted. As underlined above, water desalination emerges as a competitive option.

Current developments show an increasing trend in relation to the total desalination capacity has been increasing in all three states, with Florida leading in brackish groundwater and river desalination, followed by brackish groundwater desalination in California and Texas. Seawater desalination is very limited in all three states, despite their close proximity to the ocean, due to the fact that seawater has increased treatment costs (Ziolkowska & Reyes, 2017).

Based on Table 7-9, Florida shows the highest number of plants, followed by California. As of 2013, desalination plants in California, Florida, and Texas made up 45% of the total number of all operating desalination plants in the United States, while they provided 66% of the total desalinated water in the country. Moreover, RO accounts for 68.5% of the total desalinated water in the country. The production of desalinated water for drinking purposes in the three states makes 77% of desalinated water for this customer group in the United States, while 53.5% is for power generation, and 31% for the industry sector. In general, it can be deducted that until now desalination is seen as a supplemental water option (Ziolkowska & Reyes, 2017).

7.4.5.1 Desalination in the U.S.: California

The development of desalination capacity in California is explained by the large number of low-capacity plants: 60 plants producing water for municipal purposes at a total capacity of 208 MGD. This makes 61% of all desalination plants and 71% of the total desalination in the entire state of California. The smallest desalination plant with its daily capacity of 0.02 MGD is located in San Luis Obispo County in Santa Margarita, while the largest plant in San Bernardino County in Yucaipa produces 12 MGD (Ziolkowska & Reyes, 2017).

Two examples from California will be explained. The first example is the Santa Cruz seawater RO desalination plant in the City of Santa Cruz Water Department and Soquel Creek Water District in 2008. The plant had expected capacity of 2.5 MGD and aimed at mitigating several water scarcity-related problems in the county such as aquifer depletion, drought conditions, endangered environmental flows, and aquifers contamination because of saltwater intrusion caused by over-pumping (SCWD2, 2014). The pilot operation of the desalination plant in Santa Cruz in 2008-2009 at the capacity of 0.07 MGD was successful, while the 2013 Environmental Impact Report for the project found only insignificant environmental impact on marine life (SCWD2, 2013; Cooley et al., 2013). The plant envisaged to be transformed from a desalination plant to a direct-to-potable water recycling facility. After years of planning, the Santa Cruz City Council stopped the project, one year before public vote due to strong opposition from stakeholders. The Santa Cruz plant constitutes a single example of the complexity in the process of designing a desalination plant, including environmental assessments and permits that can take up to several years in waiting time. This proves one of the discussed challenges of investment risks in the short or long term.

The second example is a best-practice example. The Claude "Bud" Lewis Carlsbad Desalination Plant is a seawater RO desalination plant that started commercial operation in December 2015 (SDCWA, 2018). The plant is the largest seawater desalination plant in the Americas providing 54 MGD and aspires to meet approximately 10% of the region's water demand – about one third of all the water generated in the county. It will alleviate demand for water from traditional sources (Colorado River, Northern California, groundwater aquifers, and local surface water). The planning process took 12 years, while the state's permitting process took over 6 years. The San Diego County Water Authority and Poseidon agreed on a 30-year water purchase contract for the total water output of the plant (SDCWA, 2018).

The total capital costs for the plant amounted to approximately $1 billion, which makes it one of the most expensive plants in the United States. Total O&M costs (including pipeline distributing water to the community) are estimated at $49-54 million annually. More specifically, the 10-mile pipeline cost about $159 million, while the purchase of land amounted to $ 537 million. Additionally, capital costs for intake-related upgrades are estimated at $38 million (2016 dollars) while the operating costs are projected to increase by $3.6 million per year (SDCWA, 2018).

The positive socioeconomic impacts of operating the plant are the following: 2500 direct and induced new jobs and economic output of $350 million over 2 years, while once in operation, the plant will have 18 full-time employees, support 500jobs (direct, indirect, and induced), and contribute $50 million in estimated annual spending to the county's economy (SDCWA, 2018). Other indirect benefits include the operator's commitment to be net carbon neutral over 30 years through the purchase of carbon offsets and energy recovery technology (116 million kWh/y, reducing CO_2 emissions by 42,000 metric tons annually), while it is restoring 66 acres of wetlands in San Diego Bay. This will be achieved by excavating and grading a former salt production pond to create a number of coastal habitats crucial for various fish and bird species. Finally, the operator is preserving the 400-acre Agua Hedionda Lagoon (SDCWA, 2018).

In relation to water prices, the Water Purchase Agreement between the South Diego County Water Authority and Poseidon, the project developer, has set the price of water at $2,125 to 2,439 per acre-foot in fiscal year 2018. The first 48,000 acre-feet of water purchased each year will cover the fixed costs of the project and the variable costs of water production. A further option foresees the purchase of an additional 8,000 acre-feet per year at a lower rate that reflects only the variable costs of incremental water production. Typical monthly costs range at $5 per household, at the low end of the Water Authority's 2012 forecast. The Water Purchase Agreement allows for annual price increases for inflation estimated averaging 2.5 % per year. In contrast, the average increase per year in imported treated water rates imposed by the Metropolitan Water District of Southern California from 2008 through 2018 is 8%. In addition, Poseidon is entitled to increase its price to adapt to changes in law or regulations that generally apply industry-wide to water treatment facilities or wastewater dischargers. These cumulative increases are capped at 30% over the 30-year term of the agreement (SDCWA, 2018).

7.4.5.2 Desalination in the U.S.: Florida

As the champion in terms of desalination, the state of Florida shows a distinct example of how desalination can be used for various purposes. The largest seawater desalination plant in the state is located in Tampa Bay and uses RO to produce 25 MGD (Tampa Bay Water, 2010). It is located next to Tampa Electric's (TECO) Big Bend Power Station, which withdraws and discharges up to 1.4 BGD of seawater from Tampa Bay, using it as cooling water for the power plant. The plant is a public-private partnership between American Water- ACCIONA (operating the plant), the Southwest Florida Water Management District (responsible for managing the public's water resources in 16 counties of West Central Florida), and Tampa Electric Company (leasing the 8.5-acre plant site to Tampa Bay Water and providing electricity and source water for the desalination plant) (Tampa Bay Water, 2010).

The plant resumed full operation in 2007 and offers unique features that were discussed in the SWOT analysis. At the plant produces at full capacity around 19 MGD brine with its salinity twice as high as the feed water (seawater). Brine is returned to the Big Bend's cooling water stream and blended with up to 1.4 billion gallons of cooling water, which allows for achieving a blending ratio of up to 70:1. At the point of entering and mixing with bay water, brine salinity is on average only 1-1.5% higher than seawater in Tampa Bay, well within the environmental limits (Tampa Bay Water, 2010). Furthermore, the plant uses water from Tampa Electric's Big Bend power plant, which eliminates any potential risk of fish entrapment through the intake system. Cooperation with the power plant and the warm temperature of the power plant's cooling water combined with relatively low salinity of the Tampa Bay seawater is a benefit to optimizing the RO process and keeping costs down (Tampa Bay Water, 2010).

Finally, one can assume that desalination plant is an excellent example of how environmental concerns can be curbed, if these are taken carefully into consideration.

7.4.5.3 Desalination in the U.S.: Texas

The Southmost brackish groundwater RO desalination plant has production capacity of 7.5 MGD and an expected lifetime of 50 years from the start of operation in 2004. The plant is located near the Gulf of Mexico and the Texas-Mexico border outside of Brownsville, Texas. It is owned and operated by the Southmost Regional Water Authority and a consortium of six partners including: Brownsville Public Utilities Board, City of Los Fresnos, Valley Municipal Utilities District No. 2, Town of Indian Lake, Brownsville Navigation District, and Laguna Madre Water District (SRWA, 2014; Sturdivant et al., 2009). The plant represents a successful enterprise example of how desalination costs can be reduced, making desalination a viable and feasible solution.

Triggered by the rapid urban growth in the area, the Southmost desalination plant utilizes brackish groundwater from the Gulf Coast aquifer (Sturdivant et al., 2009) with the approximate feed water salinity levels of 3500 ppm. The desalination process reduces the salinity level down to 300-475 ppm (Sturdivant et al., 2009), which is below the maximum level (500 ppm) set by the US Environmental Protection Agency (EPA) for drinking water (Arroyo, 2005). Concerning production efficiency, in the first operation year (2004) was only 13% of the total design capacity. However, this increased up to 67.3% in 2007 and is anticipated to further increase up to 94%. The RO system of the plant operates at a very high recovery rate of 75% (Sturdivant et al., 2009).

Brackish groundwater with a lower salinity (compared to seawater), which is used by the facility reduces energy costs for the desalination process, while it disposes brine to the Gulf through a drainage ditch and ship channel extending to the Laguna Madre, thus reducing the total desalination costs. The original construction costs of the plant amounted to $29 million, with the 2014 O&M costs of $3 million. The electricity costs made 23% of the O&M costs, while costs of chemicals accounted for 40% of the O&M costs. Furthermore, the Southmost desalination plant initiated the installation of an additional pretreatment phase for the RO process, consisting of 12 MGD microfiltration membranes for arsenic and iron removal. In this way, the plant capacity has been expanded up to 11 MGD for an additional cost of $13 million. Finally, it has been estimated that wells/ pumps need to be replaced every 3 years, which would create costs of $200,000, while the membranes are replaced every 6 years for $700,000 (Sturdivant et al., 2009).

7.4.6 Desalination in the U.S.: Achieving sustainability of water resources, aquatic ecosystems, economic growth and social equity

Based on the analysis above, one can draw different conclusions concerning the state of desalination in the US. One the one hand, it can be assumed that desalination bears some initial cost that are very high, but it can be regarded as an alternative water supply option in the future. On the other hand, desalination development many numerous negative effects on the environment and this is why it should be considered with caution.

In any case, desalination is seen basically either as an economic investment or as a plant with negative external effects. The question that emerges is where sustainability fits in. Recent research on that field shows that there is an increasing trend on that subject. Sustainability in desalination aims to combine its three pillars, economic, environmental and social and based on that a decision on the construction of the desalination plant can be approved.

Gude (2016) has made an extensive presentation of the desalination sector globally and focused on the issue of sustainability. Desalination as an alternative water supply is based on factors and drivers that are basically context- and region specific. Climate change, less precipitation, extensive droughts, economic growths are entering this equation. Implementing sustainable desalination is a very crucial and important decision and should be based on certain criteria. These can be summarised in Figure 7-5.

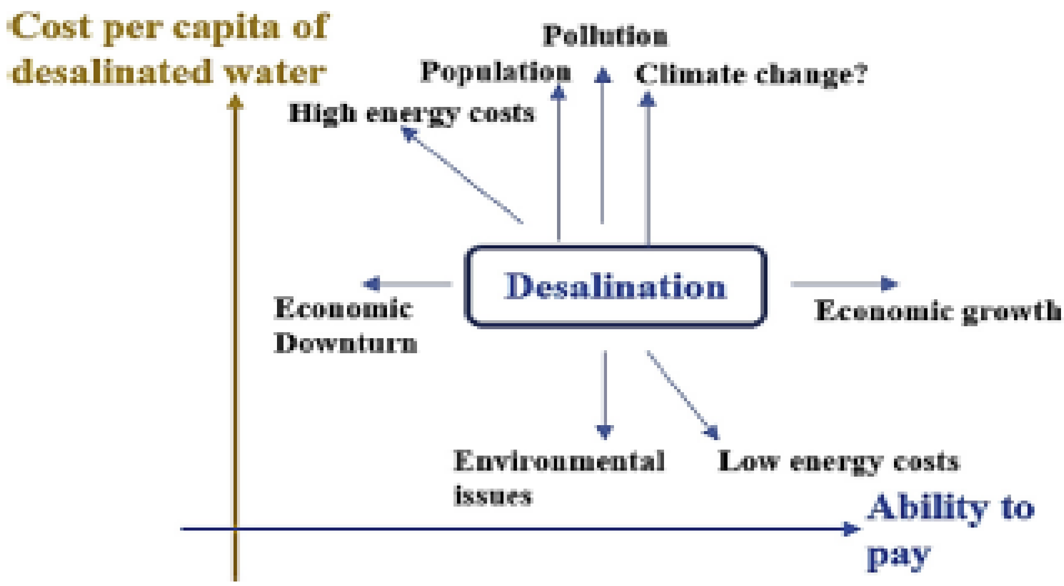

Figure 7-5: Energy, environmental and economic drivers affecting desalination. Source: Gude, 2016.

Figure 7-1 can very explicitly describe how realization of desalination plants should take place if sustainability is taken into consideration. In general, constructing a desalination plant is contingent on very region- specific factors and parameters, while the timely approval of a decision plays also a very important role, as this defines the price of water as well as its value (Gude, 2016).

Another perspective is presented by Ziolkowska and Reyes (2016b). They have carried out an analysis on the impact of several socio-economic variables (population growth, GDP, crude oil price, and water withdrawals) on the developments in the desalination sector. Based on a simple regression analysis, only two of the variables (population growth and

GDP) were found statistically significant and determining the number of new desalination plants and the desalination capacity in the US, with the population growth being a more significant variable than GDP (Ziolkowska and Reyes, 2016b). Despite the fact that this is only one research result, it clearly shows that desalination depends on a social factor. This can also be validated as population growth was seen as crucial factor in other reports (Gude, 2016; DOE, 2014).

A further attempt quantifying sustainability in the desalination is presented in Lior (2017). Lior (2017) uses a detailed mathematical definition of sustainability, based on which desalination can be assessed.

At first, a sufficient number, i, of metrics, Mi (most often called indicators) that measure the environmental, economic and social impacts of the considered project/development are chosen, while relative weights (w_i) are defined.

$$CSI=\sum_i M_i(\vec{x}_{ij})\, w_i(\vec{y}_{ik}) \text{ or some other aggregation of the } M_i w_i \text{ products} \quad (1)$$

$$\begin{aligned} CSI &= \sum_i M_i(\vec{x}_{ij})\, w_i(\vec{y}_{ik}) \text{ or} \\ &= \prod_i M_i(\vec{x}_{ij})\, w_i(\vec{y}_{ik}) \text{ or some other aggregation} \end{aligned} \quad (2)$$

Where:

x_{ij} the j system parameters that affect the metric M_i

y_{ik} the k system parameters that affect the weight wi;

i index of a metric-weight pair (Mi-wi)

j index of a metric (Mi) - dependence parameter x_{ij}

k index of a weight (wi) - dependence parameter yi_k.

As shown in Eq. (2), the metrics and their weights are usually functions of some system parameters, marked here as x_{ij} and yi_k respectively, and each one of these, in turn, can be expressed as a function of the system's component variables, i.e.

$$\vec{x}_{ij}=\vec{x}_{ij}(\overrightarrow{C_{x,\iota l}}) \quad (3)$$

$$\vec{y}_{ik}=\vec{y}_{ik}(\overrightarrow{C_{y,\iota m}}) \quad (4)$$

where

$c_{x;il}$ the l component variables affecting the x_{ij};

$c_{y;im}$ the m component variables affecting the y_{ik};

l index of the component variables affecting the x_{ij}

m index of the component variables affecting the y_{ik}

Eqs. (2)–(5) create a composite sustainability index (CSI),

$$CSI= CSI\{M_i\left[\vec{x}_{ij}(\overrightarrow{C_{x,\iota l}})\right], w_i\left[\vec{y}_{ik}(\overrightarrow{C_{y,\iota m}})\right]\} \qquad (5)$$

Components of the CSI can be derived from an inexhaustive source of information, which can be categorised in economic, social and environmental. Many parameters that were referred to previous chapters can be used as the basis of the analysis. However, one the prerequisites are their quantification so as the CSI can be easily assessed and shows the realisation of a desalination decision (Lior, 2017). Although it is premature to test the validity of this CSI, an application of certain case studies in the U.S. would be of great interest.

In this chapter, the complex nature of the water-energy nexus was described. US were a perfect case study so as to show how water affects energy production and how water supply is affected by energy. Different aspects of the nexus were analysed and it was clear that in almost all cases one decision of the water side of the nexus could clearly affect the energy side of the nexus. Such interrelation bears a great resemblance and fit perfectly into the concept of co-evolution (Norgaard, 2006). Both sides of the nexus should evolve together and they are related and interdependent. Consequently, a decision that is based on sustainability principles for a segment in the water- energy nexus may have positive spill-over effects to other segments of the nexus.

The example of desalination can validate that hypothesis. Water desalination may emerge as an alternative sustainable water supply option. This is mainly due to two facts, climate change and population growths. As aquifers and water resources remain scarce and are going to be depleted, in parallel with increased population mainly in urban areas, water desalination gains as an even more preferable option. Nevertheless, certain factors should be taken into consideration, because desalination development is entwined with environmental, climate but also social concerns. If these are tackled and clarified to some extent, then desalination can be regarded not only as a viable but also as a sustainable solution for water provision.

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Chapter 7: The “Water- Energy Nexus”: The case of the United States

Chapter 8: Conclusions

"Water, water, everywhere,
And all the boards did shrink;
Water, water, everywhere,
Nor any drop to drink."

Samuel Taylor Coleridge, The Rime of the Ancient Mariner.

8 Conclusions

Despite the fact that separate conclusions were presented in each respective chapter, this last chapter is dedicated to a more holistic overview that will facilitate primarily the validation of the research hypotheses, as they were stipulated in chapter 1.

Aim of the thesis was the description and analysis of sustainable development through intergenerational and intragenerational justice. Based on that analysis, an attempt was made to show that the concepts such as the Ecosystems Services Framework (ESF) and the water-energy nexus can sufficiently explain how sustainability is attained in aquatic ecosystems. Therefore the main research question was: How can sustainable development be attained in aquatic ecosystems? Is a concept or a theory sufficient to describe the sustainability of those ecosystems?

Different research questions were allocated according to their title. Consequently, the three distinct topics were identified:

- Sustainability in aquatic ecosystems;
- The interaction between economic, social and environmental system and;
- Case studies from Europe and the United States.

For each separate section of the title of the PhD thesis, specific research questions were articulated. This chapter aims at testing and validating the assumptions made in chapter 1 and at providing an answer to all these questions.

All research questions were sufficiently addressed. In addition, the research process has added significant insights and many traits could be further exploited so as to contribute further to the scientific dialogue.

8.1 Sustainable Development in Aquatic Ecosystems

The first question of this chapter was: What had happened before this definition emerged? Was this newly found term the result of policy experience of the previous decades? Did it aim at summarising and including already implemented concepts and theories? Where did it originate?

Additionally, a further question that emerged was how this term was interpreted and analysed so as to become a general policy goal. Why was such a definition formulated? Which need urged policy makers and scientist to define this concept?

Finally, another question of prime importance is how this definition of sustainable development was employed and implemented. Did the term retain its core elements? How has it contributed as a main policy goal? Was its position further weakened or strengthened throughout the last years?

One of the most interesting conclusions is that the concept of sustainable development was not born with the so- called “Brundtland Report” in 1987. The roots of sustainable development and sustainability date back to the 17th century while the term was coined in the 17th century (Grober, 2007). Interestingly, the term was operationally used in the forestry sector and is the dominating doctrine for two centuries now. But it is not until the post war era, where the term escaped from the restricting limits of the forestry discipline and gained a more ample use. Its definition as it is widely known is more or less, the acceptance of the term as policy goal and its successful introduction to the policy agenda, waiting to be implemented.

The definition of sustainable development as a concept from a scientific perspective paved the way for the introduction of the term in a policy context. This is the point at which sustainable development enters into the politics arena, where conflicted and interrelated interests struggle to impose their interpretation of sustainability.

Sustainable development as an ultimate policy goal started to appear in various global “mega conferences” after 1987. Firstly, the United Nations Conference on Environment and Development (UNCED) took place in 1992 in Rio and constituted the third “mega conference” (after Stockholm and Nairobi in 1982). The result of this conference was the Rio Declaration was merely a repetition of the continuous debate- the relationship between North and South- that has already started in Stockholm in 1972. As this is beyond the scope of the thesis a more detailed overview of that matter will not be described. So, the Rio Declaration designed a set of guiding principles based on which national governments and international organizations should implement their environmental policies. There is, for example, an urge to adopt the so-called “polluter-pays-principle” as well as the “precautionary principle”. Additionally, the Declaration underlined the need for increased democratic participation and for an environmental impact assessment of development schemes (UNCED, 1992).

Secondly, in 2002, more than 22,000 people attended in Johannesburg, South Africa the United Nations World Summit on Sustainable Development (WSSD). In general, Johannesburg was also the proof that the term ‘sustainable development' had gained policy acceptance. Even though some argued that the term had lost its ‘edge’ and was mostly being used rhetorically, the fact remained that it had also become a political necessity. At best, Johannesburg was viewed as a chance to advance the agenda that had been set by Rio; at the very least, it offered the opportunity “to keep the Rio agenda alive” (Sibley, 2007).

Thirdly, the United Nations Conference on Sustainable Development (UNCSD), also known as Rio 2012, Rio+20, or Earth Summit 2012 was the third international conference on sustainable development aimed at reconciling the economic and environmental goals of the global community. A product of the conference was the report "The Future We Want". The report supports the design of Sustainable Development Goals (SDGs), a set of measurable targets aimed at measuring and supporting sustainable development on a global level. The initial thought behind SDGs is that they will pick up where the Millennium Development Goals leave off. Consequently, such a thought aims at the critics of the MDGs, as they were advocating that these specific targets failed to address the role of the environment in development. Apart from that, the UN Environment Programme (UNEP) is promoted to be the “leading global environmental authority”. For this reason eight key recommendations are defined, including strengthening its governance through universal membership, increase of its financial resources and empowerment of its engagement in key UN coordination bodies.

Sustainable development and sustainability have followed a very interesting trajectory. In line with the primary assumptions, the term has been included as a policy parameter since the 16th century. In some cases such as forestry sustainability was hailed as a core goal and peculiarly not always environmental. After World War II, the concept gradually gained in importance due to the visibility of numerous environmental problems caused by the rapid industrialisation. Finally, sustainable development entered the realm of global environmental policy. Since 1987, when the notion of sustainable development was officially “born”, the concept was subject to further interpretations. Such interpretations were due to the vagueness of the concept but at the same time it was regarded as a contested concept. Different stakeholders, politicians, organisations and epistemic communities aimed at adapting and defining sustainable development according to their needs. The future of sustainability is basically known, as the term will be defined in a more or less “business-as-usual” way. This can be observed by the last two conferences in 2002 and 2012. A careful insight on the politics on sustainable development is deemed useful so as to validate or perhaps reformulate its trajectory of the notion of sustainable development. Even if the notion has lost the initial ambitions and uniqueness, it can surely play an important role as a more operational and quantifiable contest such as the SDGs.

8.2 The interaction between economic, social and environmental system

In relation to the second section of the PhD thesis, it was explained that this was merely an interpretation of the sustainable development definition.

Consequently, the next question that emerged was what interpretation of sustainable development this PhD thesis should attempt to analyse. Furthermore, how can this selection be explained? What are the parameters that direct the research to that?

On the one hand, the topic of intergenerational justice was described. Questions that are related to intergenerational justice are how much do we sustain and how much should we sustain? If those two questions have been answered then the research question can be sufficiently answered. More specifically, the main question was merely deontological. In other words, should the current generation bequeath something to the next generation and how? This chapter offered a concise analysis of sustainability viewed from the perspective of intergenerational justice.

For that reason the PhD thesis focused on the discipline of political philosophy that has engaged in that discussion for centuries. From the abundance of theories concerning intergenerational justice, the theory of Rawls (1971) was selected as the one that could fit the basic traits of sustainability. Nevertheless, it was observed that the Rawls’ theory could not be directly adopted, before some amendments were implemented. Instead a “post structuralist” adaptation was attempted. In that way, the theory was amended in a way so its final product coincided with Gosseries thesis that sustainability can be seen a sufficientary concept, i.e. “Brundtland’s sufficientarism” (Gosseries, 2011). Again some flawed assumptions concerning the definition of sustainability have been observed. However, as it was mentioned above, this is the “raison d’ être” for this thesis and based on that, the research attempt aims to investigate further the interrelation between intergenerational justice and sustainability.

On the other hand, the topic of intragenerational justice was presented. This was considered as the crucial topic of satisfying human basic needs. Consequently, the question could be summarised as follows: what do human beings consider as important for their own well-being that is also consequently crucial for sustaining and bequeathing to the next generations? Furthermore, another question was: Are there specific needs that should be satisfied in order for an individual to attain a certain “threshold” of well-being”? In addition, the next question that emerged was : How can this threshold for this person could be defined? Are there any theories that specify the basic needs of a human being?

This chapter, dedicated to intragenerational justice, began with a thorough description of Amartya Sen’s approach, known as the Capability Approach. Its main traits as well as its premises were described. Interestingly, Sen aims at constructing a flexible concept, that will be adapted to the research goals and for that reason he does aim to construct a theory. Similar to that approach but having other principles, Martha Nussbaum’s approach on basic needs was presented, as both scientists initiated the development of that approach together. Nevertheless, Nussbaum has opted for a more determined analysis of basic needs. In addition, Max Neef’s approach on basic needs was presented. In contrast with the other two, Max Neef was keen on presenting a very detailed and comprehensive list of basic needs that satisfy an individual’s well-being.

After presenting the three basic approaches, three other approaches, that attempted to combine intragenerational justice with sustainability were presented.

Rauschmayer and Leßmann try to integrate sustainability explicitly. While Rauschmayer attempts to merge Max Neef’s concept with the notion of sustainability, Leßmann’s efforts focus on putting together the Capability Approach and sustainability. Agency plays the key role in his analysis that ensures the harmonic co-existence of two concepts with different characteristics. In any case, sustainability is viewed as a policy goal in specific policies that coincide with the fulfilment of human well-being. Ortrud Leßmann tries specifically to create a unit for analysing sustainability and subsequently well-being as well as ecosystem services. This trait will be adopted and developed further in Chapter 5, as ecosystems systems expect to fulfil the main research question, i.e. the attainment of sustainability. However, more elaboration is needed for both attempts.

Breena Holland tries to provide a more extensive account on how environment can be inserted in the well-being equation. Here sustainability is implied and is firstly defined as “ecological meta-capability”. Furthermore, “capability thresholds and ceilings” are defined. Capability thresholds refer to the minimum level an individual’s basic capabilities should be assured, while capability ceilings refer to the maximum levels of basic capabilities an individual is allowed to attain. If those ceilings are surpassed, this can lead to harming other individual's basic capabilities. Such ceilings are directly correlated and defined by ecological thresholds. This remark points implicitly to sustainability that shares the same characteristic. Surely, Holland does try to provide a more practical account of how basic capabilities can be assured, by ensuring a viable environment. Nevertheless, her attempt is focusing on individual well-being. As her framework is meticulously sketched, her effort can serve as a useful theoretical foundation, which can be expanded to include sustainability explicitly. Here the role of agency may provide the necessary link so as the CARR can be elaborated.

After analysing the notion of sustainability and looking into the concept of well-being, the analysis aims to focus on concepts and metrics relating directly or indirectly to sustainable development. Is there such a metric? How is sustainability expressed within this framework and how is well-being assessed?

Here ES framework has been identified as the primary candidate. Apart from that, one should look at how sustainability is integrated in the ES framework. This is basically encrypted in the way ES are categorised. Beyond the Millennium Assessment (MA, 2005), other ES framework concepts are "limited" to defining three basic categories of ES. If one looks at them carefully, one could find a direct interpretation of the three pillar model of sustainability. This means that regulating services corresponds to ecological sustainability, provision services to economic sustainability and finally cultural services to social sustainability (Grunewald and Bastian, 2015). Therefore, by assessing the different categories of ES, one can also estimate the situation of sustainability partially or as a whole.

Two specific traits of the ES framework may be considered as an invaluable addition and interpretation of well-being and sustainability. On the one hand, the well-being is directly framed as the primary goal of the Framework. On the other hand, the attainment of well-being is succeeded by measuring the status of the ecosystems. Consequently, well-being is directly correlated with the environment and its current and future status. Defining well-being in all theoretical ES approaches have an input of aforementioned theories and concepts such as that of Sen (1999) and Nussbaum (2011). Nevertheless, the centre of attention is twofold. Firstly, the focus of attention was at human well-being through the help of ES, as flows of services that are translated as benefits to humans. Secondly, the environment should be seen as the habitus, i.e. "oikos" of human beings; therefore well-being attainment is contingent on the situation of the environment (stocks) and their supply (flows).

Additionally, the EPPS framework presents an interesting trait that again has been referred to above. This is the trait of "potential", which is here seen as the potential of an ecosystem to provide ES. This is the same mechanism that lies behind Sen's Framework (1999) that considers capabilities, i.e. what an individual can potentially achieve, in contrast to the functionings aspect. This notion is transferred to ecosystem in the ES Framework, stressing the need of focusing on potential, i.e. what an ecosystem can possibly supply, as in many cases, the ecosystem can provide those potential services in the future and/or offer an augmented/ reduced level of existing ES.

In conclusion, it is apparent that ES can provide a sufficient concept where the concept of well-being along with the concept of sustainability can be successfully integrated. Consequently, the aim of the next chapter is to articulate those theoretical implications to a practical example.

8.3 Case studies from Europe and the US

The last process of the research process was the practical application of the ES framework or even other concepts that focus on sustainability. The first question : Did a case study example exist of how ecosystem services could be assessed and monetarily valuated. Furthermore, another question of the chapter was basically how ecosystem services could be applied in practice, how could existing concepts and policies help formulate the value of ecosystem services and how could be this be used further for policy making.

This chapter was dedicated to the estimation of the value of ecosystem services in specific geographic areas. More specifically, the value of three ecosystem services was estimated. These were the following:

- Provisioning service (freshwater provision)
- Provisioning service (provision of agricultural water)
- Provisioning service (water for electricity production)

The Integrated River Basin Management Plans in the Water Districts of Central and Western Macedonia (Ειδική Γραμματεία Υδάτων, 2014a; 2014b) were the main source for the calculation of the value of all three services. The methodology employed in both Management Plans was followed for the estimation of the three provisioning services.

Freshwater provision and water for agricultural use were treated jointly, as they were regarded as competitive and major uses in both WDs. In some cases, the financial, environmental and resource cost was calculated and was therefore treated as equal to the value of both ecosystem services.

A slightly different approach was employed for the use of water for electricity production. Principally, the financial and resource cost solely of large hydroelectric plants was calculated. However, the benefits embedded by the use of large hydroelectric plants were additionally calculated and therefore the value of those benefits could better reflect the value of water for electricity use. Such positive external effects included the production of electricity with using energy sources that generate CO_2 emissions. Large hydro does not produce by-products such as CO_2 emissions. Such emissions are harmful to the environment and contribute to climate change. Consequently, large hydro generation has an implicit environmental benefit that should be estimated and taken into consideration.

The concept formulated by Koundouri et al. (2016) formed the theoretical basis for the analysis and estimation of ecosystem services value, especially for the first two provisioning services. Based on that, it was assumed that the value of the provisioning services of freshwater provision and provision of agricultural water is seen as equal to the total value/ cost of water as it was estimated in the Integrated River Basin Management Plans. Nevertheless, there was a serious omission and deviation to the methodology proposed by Koundouri et al. (2016), as the economic assessment of potential measures for sustainable water management was deliberately not taken into consideration.

It should be noted that the author was a member of the research team responsible for carrying out the economic analysis of water uses in both WDs (Ειδική Γραμματεία Υδάτων, 2014a; 2014b), which was part of the Integrated River Basin Management Plans for both WDs (Ειδική Γραμματεία Υδάτων, 2014e; 2014f). The main research activity was the estimation of cost recovery ratio for the major water uses in the WDs. Based on the methodology proposed by WATECO (2002), not only the financial cost should be calculated. Both environmental cost and resource cost are crucial cost categories that should be estimated and can define the so-called Total Economic Value of Water (Kumar et al., 2009).

After extensive discussions of stakeholders and experts in that field, the methodology based on which all three cost categories was estimated was defined. If one looks carefully at the methodology for the calculation of environmental cost for both provisioning services, it can be noted that future projects ensuring the sustainable water management in both WDs are included in the calculation of environmental cost. Such projects were also included in the Integrated River Basin Management Plans (Ειδική Γραμματεία Υδάτων, 2014e; 2014f). In other words, environmental cost was especially in the case of freshwater provision equal to the realisation of future projects that are directly linked to the sustainable water management.

The calculation of resource cost is calculated correspondingly and it refers to foregone benefits that are mainly due to over extraction of groundwater, thus creating an additional cost that will burden water users in the future, due to the expected lack of water reserves for the satisfying the needs/ demand of all water uses. The approach used for the use lead to conservative estimation of those future costs and could also be indirectly seen as an implicit cost, which should be allocated to the respective water uses and should lead water uses to conform to a more sustainable water management approach (Bithas et al., 2014).

Consequently, potential measures for sustainable water management as stipulated in Koundouri et al. (2016) have already been included in the estimation of value of water in both WDs. Therefore, there was no need in adding those measures as both environmental and resource cost estimation took into consideration future projects and measures with which the sustainable management of water resources in the RBs of the WDs can be achieved. In other words, the “gap” between initial and desired water status as formulated in the WFD was monetized and integrated in the total economic value of water. Theoretically, the adding up of potential measures and projects to the economic analysis that was already carried out could be regarded as “double counting”, thus over estimating the overall value of water in those WDs. This is a serious but unfortunately a common pitfall in estimating the value of environmental goods such as water and should be avoided (Kumar et al., 2009). In the case of the economic analysis in WD10 and WD09, this “double counting" did not take place, but it was important to clearly and adequately justify the omission of that calculation and the deviation of the methodological framework proposed by Koundouri et al. (2016).

Another remark concerns differentiation with the estimation of the first two provisioning services (freshwater provision and provision of agricultural water) and the third provisioning service (water for electricity use). As described above, the framework employed by Koundouri et al. (2016) was used for the estimation of the first water related ecosystem services. Based on that, water value was defined as the sum of three cost categories. However, for the service "water for electricity use" an alternative approach was followed, despite the fact that these cost categories were also calculated. The reason behind this is linked with the nature of water and energy as goods.

On the one hand, water is both a depletable and renewable source. This depends on the source of water, i.e. surface water or groundwater. While surface water is a renewable supply, whose supply is contingent on weather conditions, groundwater is also renewed by percolation of rain or melted snow, but most was accumulated over geologic time and, because of its location, cannot be recharged once it is depleted (Gleick, 2000). Additionally, in relation to surface water its allocation includes distributing a fixed renewable supply among competing users, while for groundwater, the withdrawing of water now does affect the resources available to future generations. Therefore, the allocation over time is a crucial aspect (Tietenberg and Lewis, 2016).

Based on all of the above, water has unique features as an environmental good. Firstly, there is a hierarchy concerning the sources of withdrawal based on cost, demand and availability. In other words, surface water is primarily withdrawn; while groundwater remains the second best option, as it is more less cost- effective but it can be the sole option where there is no surface water. Furthermore, there are competitive water uses, as it was described in previous chapters. Nevertheless, there is no production of water, but one speaks about water treatment, maintaining water quality standards and attaining an efficient and sustainable water allocation and distribution (Tietenberg and Lewis, 2016). With the exception of desalinisation, there is no production unit for water under the current state-of-the-art technology. The quality issue makes water difficult to "transfer" water over long distances, so water must be allocated in a constrained geographical region (Hardberger, 2013).

On the other hand, energy is a more "flexible" source. There are competitive electricity production sources such as oil, gas, photovoltaic, wind and surely water. All these can produce the good "electricity". Furthermore, electricity can be transferred over long distances without any effects to its quality. Quality is not an issue per se, i.e. there is no electricity of lower quality that cannot be consumed. However, the "quality" is directly linked with the source of production. Consequently, there is clean energy that comes from renewable resources such as sun, water, biomass and water (WWF Ελλάδα, 2017). Other electricity production sources such as oil, coal and gas entail CO_2 emissions, which are harmful to the environment, pollute the atmosphere and contribute to the greenhouse effect and to climate change. In microeconomic theory, those effects are defined as external and one goal of environmental policy is to internalise those effects, so as to reflect the real cost of electricity production (Μπίθας, 2011).

Therefore, as there is no competitive water production, one can look only at the allocation of water between competitive water uses and how these affect the sustainable water management. So as to evaluate water related ecosystem services such as freshwater provision and irrigation water, the cost of supplying water to those uses should be taken into consideration, at least at a first stage (Grizzetti et al., 2016). Due to the fact that the categories of ecosystem services are thoroughly defined and focus on very specific parameters (effect on human well-being), estimating the value those provisioning services can equal the total cost of providing those services.

Apart from that, the provisioning service "water for electricity use" has other features. Water is here used as an input for the production of a good, i.e. electricity that affects human well-being. In parallel, there also other inputs that produce the same good. In our case in WD09, the competitive electricity production source is lignite fired power plants. However, these entail CO_2 emissions, an external effect that should be taken into consideration. In contrast, large hydro is a cleaner source of energy as there are no CO_2 emissions involved in the production process. As the water related ecosystem service is examined in the analysis and there is no comparative analysis of electricity production sources, it would be a serious omission, if the environmental benefits of producing electricity by large hydroelectric plants are not taken into account. By looking into only the cost side of large hydro and considering it equal to the value of the provisioning ecosystem service can be regarded as deficient. In that case, a more holistic approach was needed, so as the additional positive external effects can be integrated into the value of the specific ecosystem service. Thus, the value of the provisioning service "water for electricity use" was regarded equal to the benefits the electricity production by large hydro i.e. revenues by selling the generated electricity and the positive environmental benefits by producing clean energy.

The value of the three ecosystem services is presented in Table 8-1, Table 8-2 and Table 8-3.

Table 8-1: Estimation of the provisioning service (provision of agricultural water) in WD10 and WD09. Source: Ειδική Γραμματεία Υδάτων, 2014a; 2014b.

RBs	Financial Cost (Water Supply	Financial Cost (Industry)	Environmental Cost (Water Supply)	Environmental Cost (Industry)	Resource Cost (Water Supply)	Resource Cost (Industry)	Total
Axios €	19,611,330 €		3,971,524 €	776,725 €	606,422 €	331,268 €	**25,297,269 €**
Gallikos €	8,055,555 €	7,231,586 €	1,297,069 €	532,959 €	150,699 €	542,428 €	**17,810,296 €**
Chalikidi €	79,190,082 €		13,427,716 €	476,513 €	820,009 €	112,857 €	**94,027,177 €**

RBs	Financial Cost (Water Supply	Financial Cost (Industry)	Environmental Cost (Water Supply)	Environmental Cost (Industry)	Resource Cost (Water Supply)	Resource Cost (Industry)	Total
Athos €	885,704 €						**885,704 €**
Total WD10 €	**107,742,671 €**	**7,231,586 €**	**18,696,309 €**	**1,786,197 €**	**1,577,130 €**	**986,553 €**	**138,020,446 €**
Aliakmonas €	51,745,540 €		12,902,829 €	1,109,013 €	985,297 €	1,088,644 €	**67,831,323 €**
Prespes €	2,473,450 €		886,238 €	6,845 €			**3,366,533 €**
Subbasin Prespes €	80,944 €						**80,944 €**
Total WD09 €	**54,299,934 €**		**13,789,067 €**	**1,115,858 €**	**985,297 €**	**1,088,644 €**	**71,278,800 €**

Table 8-2: Estimation of the provisioning service (provision of agricultural water) in WD10 and WD09. Source: Ειδική Γραμματεία Υδάτων, 2014a; 2014b.

RBs	Financial Cost (Organised Irrigation)	Environmental Cost (Organised Irrigation)	Environmental Cost (stabled livestock	Environmental Cost (Private Farming)	Resource Cost (Organised Irrigation)	Resource Cost (Private Farming)	Resource Cost (Stabled Livestock)	Total
Axios €	28,788,494 €	1,177,248 €	269,122 €	374,768 €	63,659 €	6,302,276 €	50,615 €	37,026,182 €
Gallikos €	243,841 €	17,732 €	65,302 €	32,397 €	14,869 €	1,472,038 €	39,660 €	1,885,839 €
Chalikidi €	109,038 €	14,443 €	340,100 €	187,255 €	70,977 €	7,026,770 €	26,678 €	7,775,261 €
Athos €								0 €
Total WD10 €	**29,141,373 €**	**1,209,423 €**	**674,524 €**	**594,420 €**	**149,505 €**	**14,801,084 €**	**116,953 €**	**46,687,282 €**
Aliakmonas €	9,193,335 €	441,844 €	709,054 €	231,634 €	1,347,624 €	12,128,617 €	246,105 €	**24,298,213 €**
Prespes €	276,365 €	82,159 €	112,906 €	113,395 €				**584,825 €**

RBs	Financial Cost (Organised Irrigation)	Environmental Cost (Organised Irrigation)	Environmental Cost (stabled livestock	Environmental Cost (Private Farming)	Resource Cost (Organised Irrigation)	Resource Cost (Private Farming)	Resource Cost (Stabled Livestock)	Total
Subbasin Prespes €	211,970 €	24,640 €	14,678 €	14,741 €				**266,029 €**
Total WD09 €	**9,681,670 €**	**548,643 €**	**836,638 €**	**359,770 €**	**1,347,624 €**	**12,128,617 €**	**246,105 €**	**25,149,067 €**

Table 8-3: Total value of benefits of PPC's activities. Source: Ειδική Γραμματεία Υδάτων, 2014b.

Large Hydro	Electricity Production (€)	Environmental Benefit (€)	Total Value (€)
Total	**85,363,871 €**	**20,486,918 €**	**105,850,790 €**

Finally, there is one last remark concerning the valuation of water related ecosystem services with the assistance of the WFD. Surely, the focus of WFD is different from that of ecosystem services valuation. More specifically, economic analysis under the framework of WFD focuses ultimately on estimating the cost recovery ratio of different water uses (WATECO, 2002). This will serve as the basis so as water pricing principles are founded on the full cost recovery principle. Despite the fact that there are conceptual frameworks that use WFD as a tool for evaluating water related ecosystem services (Bastian et al., 2012; COWI, 2014; Wallis et al., 2011) there is a pure ontological question concerning the need for ecosystem services valuation. Surely, there are concerns as to how this valuation can be practically employed. WFD has set clear goals for this, but scholars have disagreed on the matter. Kallis et al. (2013) engaged with the question "to value or not to value?" reformulating the question as "when and how to value with money?" and "under what conditions?". As a consequence, four criteria for an economic valuation were formulated (Kallis et al., 2013):

- environmental improvement;
- distributive justice and equality;
- maintenance of plural value-articulating institutions;
- confronting commodification under neo-liberalism.

Based on these criteria, both full-cost pricing under the WFD and Payments for Ecosystems Services (PES) Schemes do not fulfil all four criteria and therefore their economic valuation should not be carried out. However, there is room for improvement as economic valuation can be calibrated and adapted to so as to conform to all four criteria (Kallis et al., 2013).

Thus, it can be assumed that economic valuation and more specifically economic assessment of ecosystem services could not be a priori rejected. However, one should be careful when to use this economic valuation as a means to a certain end.

More generally, economic valuation of ecosystem services and therefore environmental prosperity is a tool for environmental awareness. Although the contribution of environmental well-being to overall prosperity is perceived by society, the lack of valuation can undermine this contribution. Apart from any positive psychological impact, non-recognition of the essential dimensions of environmental well-being leads to direct and indirect environmental degradation and any attempt to protect it. In this way, the assessment of ecosystem services in economic terms gives above all an order of magnitude for the relative magnitude of environmental prosperity. Apart from that, it highlights the value of environmental protection and, by extension, environmental policy and should be therefore an instrument of environmental awareness, information and education (Τράπεζα Πειραιώς, 2017).

The next step after awareness-raising is to carefully draw the principles and goals of environmental policy, where economic valuation will serve as the theoretical foundation for introducing a new water pricing policy or new environmental fees and taxes. In any case, economic valuation can form the foundation, based on which new policies can be designed and implemented and could be adapted to conform to any policy goals.

In the last chapter, the complex nature of the water-energy nexus was described. The main question would be basically how water-energy nexus could be defined and how this could be described. Furthermore, could this paradigm assist in designing water and energy efficient policies that could secure the sustainability of water resources on the one hand and the efficient and clean production of energy on the other hand? Finally, were there any lessons learnt?

US was a perfect case study showing how water affects energy production and how water supply is affected by energy. Different aspects of the nexus were analysed and it was clear that in almost all cases one decision of the water side of the nexus could clearly affect the energy side of the nexus. Such interrelation bears a great resemblance and fits perfectly into the concept of co-evolution (Norgaard, 2006). Both sides of the nexus should evolve together, they are related and interdependent. Consequently, a decision that is based on sustainability principles for a segment in the water- energy nexus may have positive spill-over effects to other segments of the nexus.

The example of desalination can validate that hypothesis. Water desalination may emerge as an alternative sustainable water supply option. This is mainly due to two facts, climate change and population growths. As aquifers and water resources remain scarce and are going to be depleted, in parallel with increased population mainly in urban areas, water desalination becomes as an even more preferable option. Nevertheless, certain factors should be taken into consideration, because desalination development is entwined with environmental, climate and social concerns. If these are tackled and clarified to some extent, then desalination can be regarded not only a viable but also as a sustainable solution for water provision.

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