Voedselzekerheid

Een beschouwing vanuit drie dimensies

WAGENINGEN UR

For quality of life

Voedselzekerheid

Een beschouwing vanuit drie dimensies

Redactie: P. Berkhout

Rapport 2009-086
Oktober 2009
Projectcode 21418
LEI Wageningen UR, Den Haag

Foto's: Shutterstock

Voedselzekerheid; Een beschouwing vanuit drie dimensies
Berkhout, P. (redactie)
Rapport 2009-086
ISBN/EAN: 978-90-8615-365-7
Prijs € 19,25 (exclusief 6% btw)
88., fig., tab.

Honger is een hardnekkig probleem in de wereld. Een van de grootste uitdagingen de komende jaren is voorkomen dat het aantal mensen dat honger lijdt - nu rond de één miljard mensen - nog verder toeneemt. Het vergroten van de voedselzekerheid voor een nog altijd groeiende wereldbevolking is een vraagstuk met meerdere dimensies: een technologische, een institutionele en een economische. In dit boekje zijn drie bijdragen gebundeld, die ieder het wereldvoedselvraagstuk benaderen vanuit een van deze drie dimensies.

To combat hunger is one of the biggest challenges the world is facing today. Currently around 1 billion people are suffering from hunger. Improving food security, with a still increasing world population, is a difficult and complex task. It is a problem with multiple dimensions, a technical, an institutional and an economic dimension. This report offers three articles, each article covering one of these dimensions.

Bestellingen
070-3358330
publicatie.lei@wur.nl

Het LEI is ISO 9000 gecertificeerd.

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Woord vooraf

Voedselzekerheid is van levensbelang voor iedereen. Meer dan één miljard mensen ervaren dagelijks wat het is om honger te hebben. Aan de andere kant lijden steeds meer mensen aan overgewicht door overvoeding. Het is wrang te moeten constateren dat onbalans in de voedselbeschikbaarheid en de toegang tot voedsel zo veel problemen kan geven.

Honger kent allerlei oorzaken. De enorme toename in het aantal mensen dat honger lijdt als gevolg van sterk gestegen voedselprijzen de afgelopen anderhalf jaar, laat zien hoe belangrijk de economische dimensie is. Maar ook de manier waarop we onze landbouw- en handelssystemen hebben ingericht is van grote invloed op de beschikbaarheid van voedsel. Daarnaast is er een toenemende vraag naar biomassa voor andere dan voedseldoeleinden. Vooral de roep om biobrandstoffen speelt daarbij een rol vanwege de enorme hoeveelheden biomassa die nodig zijn om aan de politieke doelstellingen op dit vlak te voldoen.

Ter gelegenheid van Wereldvoedseldag 2009 heeft LEI Wageningen UR in samenwerking met enkele andere onderdelen van Wageningen UR drie notities over voedselzekerheid gebundeld. De drie notities benaderen het vraagstuk van voedselzekerheid vanuit de verschillende hiervoor beschreven dimensies: een economische, een technologische en een institutionele. Zo wordt een goed beeld verkregen van de uitdagingen waar de wereld voor staat om te voorkomen dat honger zich nog verder uitbreidt.

De bijdrage van Kees van Diepen (Alterra, onderdeel van Wageningen UR), Christiaan Bolck (AFSG), Niek Koning (Wageningen University, departement Maatschappijvraagstukken), Huub Löffler (Plant Sciences Group Wageningen UR) en Johan Sanders (Wageningen University Agrotechnology en Voedingswetenschappen), die het vraagstuk vanuit de technische kant benaderen, is recent geschreven. In dit artikel draait het om een feitelijke doorrekening van de technische mogelijkheden voor het verhogen van de productie van biomassa. De bijdrage van Niek Koning en Arthur P.J. Mol (Wageningen University, departement Maatschappijvraagstukken), met als invalshoek de institutionele kaders, is eerder gepubliceerd in het tijdschrift *Food Security* (2009:1). Deze bijdrage beschrijft niet alleen de werking van de verschillende markten voor voedsel, energie en bio-energie, maar koppelt daar ook een bevlogen suggestie aan om de werking te verbeteren. De bijdrage van Martin Banse, Peter Nowicki en Hans van Meijl, en (LEI Wageningen UR) met als invalshoek economie, is een geactualiseerde versie van de notitie *Why are current food prices so high* die is gepubliceerd in het voorjaar van 2008, naar aanleiding van de destijds sterk gestegen prijzen voor agrarische grondstoffen. Dit artikel geeft een overzicht van de factoren die van invloed zijn op de prijsvorming.

De eindredactie van dit boekje was in handen van Petra Berkhout (LEI Wageningen UR).

Prof.dr.ir. R.B.M. Huirne
Algemeen directeur LEI Wageningen UR

Samenvatting

In dit rapport zijn drie notities gebundeld die ieder vanuit een verschillende dimensie het probleem van de voedselzekerheid beschouwen. Het gaat om de technologisch, de institutionele en de economische invalshoek. Hierna is per deelnotitie de samenvatting gegeven.

De technologische invalshoek
In deze notitie wordt een analyse gemaakt van de volgende drie hoofdroutes om voldoende plantaardig materiaal te produceren:

A. Uitbreiding van het landbouwareaal;
B. Verhoging van de productie;
C. Verhoging van de efficiëntie van het gebruik van plantaardige grondstoffen en van schaarse inputfactoren als water, mineralen en grond.

Op basis van deze analyse worden de volgende conclusies getrokken:

1. Om de wereldbevolking in 2050 adequaat te kunnen voeden is een verdubbeling van de plantaardige productie nodig.
2. Een substantiële uitbreiding van het akkerbouwareaal is niet reëel. Wel kan het geïrrigeerde areaal nog groeien. De verdubbeling van de productie zal voornamelijk gehaald moeten worden uit een verhoging van de productiviteit.
3. Rekening houdend met biofysische en sociaaleconomische beperkingen zit er nog voldoende rek in onze systemen om de plantaardige productie grofweg te verdubbelen, mits we gebruik maken van de beste technologieën en een beleid ontwikkelen dat tijdige investeringen in het benutten van de aangegeven mogelijkheden bevordert.
4. De huidige productiesystemen laten geen grootschalige teelt van gewassen voor biobrandstoffen toe.
5. De technologische oplossingsrichtingen om de *yield gap* te verkleinen zijn veredeling en intensivering van de primaire productie door optimalisatie en *recycling* van schaarse inputs.
6. Nieuwe innovatieve concepten, zoals productie op zee, kunstmatige fotosynthese of een efficiënter gebruik van onze biomassa kunnen de grenzen van de fysische productie verder oprekken en daarmee ruimte vrijmaken voor grondstoffen voor een *Biobased Economy.*

De institutionele invalshoek
De groeiende vraag naar biomassa voor energiedoeleinden verergert bestaande risico's op het gebied van voedselzekerheid. Het is een taak voor mondiaal opererende organisaties om deze risico's te beheersen. Deze instellingen zouden ervoor moeten zorgen dat tijdig wordt geïnvesteerd in de mondiale productiecapaciteit van biomassa en in een evenwichtig gebruik van deze biomassa voor voedsel en voor andere doeleinden. Daartoe is het noodzakelijk dat de institutionele arrangementen ertoe leiden dat ten eerste de instabiliteit van voedselprijzen op de korte termijn wordt verminderd en ten tweede op de langere termijn een tekort aan voedsel wordt voorkomen. De notitie analyseert hoe de markten voor voedsel, energie en bio-energie op dit moment gereguleerd zijn. Daaruit blijkt dat het in de huidige situatie niet goed mogelijk is om prijsinstabiliteit te beheersen en het gebruik van biomassa voor voedsel of andere doeleinden in balans te krijgen. Het is daarom nodig nieuwe organen in het leven te roepen. Voorgesteld wordt een gecoördineerde aanpak van grondstoffenbeheer op mondiaal niveau in te voeren - vergelijkbaar met de *Commodity Control Organization* die ooit is bedacht door Keynes voor het beheer van grondstoffen na de Tweede Wereldoorlog - om de genoemde problemen aan te pakken.

De economische invalshoek
De stijging en zeer snelle daling van de voedselprijzen in de afgelopen twee jaar treft de gehele wereldbevolking, met name de allerarmsten. Het duidelijk in kaart brengen van de diverse oorzaken die ten grondslag liggen aan deze prijsverhoging en -daling is cruciaal om beleidsmaatregelen te vermijden die mogelijk averechts zouden kunnen werken. Dit artikel biedt een overzicht van de factoren die momenteel van invloed zijn op de voedselprijzen en helpt zo om het juiste beleid te ontwikkelen en in de komende tijd ten uitvoer te leggen. Uit het overzicht blijkt dat de grootste vijand van een hoge prijs de hoge prijs is. Met andere woorden, hoge prijzen lokken een productieverhoging uit, die uiteindelijk weer leidt tot een prijsdaling. Daar gaat enige tijd overheen. De verwachting is wel dat de prijzen - nominaal - boven het niveau van voor 2007 blijven, gegeven de groeiende vraag naar voedsel in economisch snel groeiende landen. Speciale aandacht wordt besteed aan de invloed van de huidige recessie.

Summary

Food security: A three-dimensional examination

This report combines three documents, each of which each examines a different dimension of the problem of food security. The problem is discussed from a technological, an institutional, and an economic perspective. A summary of each document is presented below.

The technological perspective
This document analyses the following three main paths towards producing sufficient vegetable material:
A. Expansion of agricultural acreage;
B. Increased production;
C. Increased efficiency in the use of vegetable-based raw materials and of scarce input factors such as water, minerals, and land.

The following conclusions can be drawn from this analysis:
1. In order to adequately feed the world population in 2050, vegetable crop production will need to increase by 100%.
2. A substantial expansion of agricultural acreage is not realistic. It is however possible to increase irrigated acreage. The 100% increase in production will need to be realised primarily by means of increased productivity.
3. Taking biophysical and socio-economic limitations into account, our systems are flexible enough to roughly double vegetable crop production, providing we make use of the best available technologies and develop a policy promoting timely expenditure on suggested possibilities.
4. The current production systems do not allow for large-scale cultivation of biofuel crops.
5. The technological solution types for decreasing the yield gap are breeding and intensification of the primary production by optimisation and recycling of scarce inputs.
6. New innovative concepts, such as offshore production, artificial photosynthesis, or more efficient use of our biomass, could further expand the boundary of the physical production, and therefore make room for raw materials for a 'Biobased Economy'.

The institutional perspective

The increasing demand for biomass for energy use is further escalating existing food security risks. Managing these risks is a task for global institutions. These should ensure timely investment in the world's capacity for producing biomass and balance the use of this biomass for foods and for non-foods. To achieve this, institutional arrangements for global food markets must fulfil two important goals: reduce the short-term price instability of food markets, and prevent a structural scarcity of food in the long term. This paper analyses how agro-food markets, energy markets and biofuel markets are currently regulated. As this regulation is ill-suited to manage food price instabilities and balance food and non-food use of biomass, new institutions need to be put in place. A coordinated system of global commodity management - not unlike the Commodity Control Organization proposed by Keynes for the post-WWII era - is proposed to deal with these coming challenges.

The economic perspective

The progressive rise and fall of food prices over the past two years is of global concern, affecting all persons, and especially the poorest. Having a clear perspective on the several causes of this price increase and decrease is essential to avoid a policy response that could be counterproductive. This guide through the factors currently influencing food prices will help to develop the appropriate policy mix to be implemented in the coming period. The overview of driving factors shows that high prices are their own worst enemy. In other words, high prices induce more production and as a result, prices go down again. This effect takes some time. Food prices, however, are likely to remain above their pre-2007 nominal levels, due to demand pressures from rapidly industrialising emerging economies. Special attention is given to the impact of the current economic recession.

1 Het technisch potentieel voor de wereldproductie van biomassa voor voedsel, veevoer en andere toepassingen

Kees van Diepen, Christiaan Bolck, Niek Koning, Huub Löffler en Johan Sanders

1.1 Inleiding en vraagstelling

De stijging van de voedselprijzen in 2007-2008 heeft wereldwijd tot onrust geleid. In een aantal arme landen veroorzaakte ze rellen en demonstraties. Inmiddels zijn de internationale voedselprijzen teruggekeerd naar het niveau van begin 2007. Was de 'voedselcrisis' van tijdelijke aard of is er voor de wat langere termijn toch reden om ons ongerust te maken over de beschikbaarheid van voldoende voedsel tegen een redelijke prijs?

Deze notitie gaat over de vraag of er vanuit technologisch oogpunt reden is om bezorgd te zijn over de toekomstige beschikbaarheid van voldoende plantaardig materiaal voor voedsel, diervoeding en niet-voedseltoepassingen (zie kaders). Met andere woorden: hoe kunnen we technisch gezien zorgen voor een duurzame landbouw, waarbij mineralen worden gerecycled, waar we de bodemgesteldheid ten minste op peil houden, waar we zuinig met schaars water omgaan, de biodiversiteit in stand houden en waar de plaatselijke bevolking verbetering van welvaart en welzijn ondervindt?

Om een antwoord te geven op de vraag of we in staat zijn voldoende plantaardig materiaal te produceren, is in deze notitie een analyse gemaakt van de volgende drie oplossingsrichtingen:

1. Uitbreiding van het landbouwareaal;
2. Verhoging van de productie;
3. Verhoging van de efficiëntie van het gebruik van plantaardige grondstoffen en van schaarse inputfactoren als water, mineralen en grond.

Bij deze benadering zijn echter twee kanttekeningen vooraf op hun plaats. Op de eerste plaats garandeert voldoende voedselproductie op zichzelf niet het uitbannen van honger. In de afgelopen eeuw - en ook nu nog - is honger voornamelijk veroorzaakt door armoede. Maar dat maakt de vraag naar de toekomstige beschikbaarheid van voedsel niet minder belangrijk. Als voedsel schaarser wordt, zal het aantal armen dat honger lijdt groter worden doordat de voedselprijzen stijgen.

Op de tweede plaats betekent een technisch potentieel voor de productie van biomassa niet dat die productie feitelijk gerealiseerd kan worden. Omdat technische input-outputrelaties gekenmerkt worden door afnemende meeropbrengsten, ligt het economische optimum onder het technische maximum. Bovendien leiden de prijsverhoudingen tussen inputs en outputs ertoe dat winstmaximaliserende investeerders bepaalde technische mogelijkheden niet zullen ontwikkelen en dat winstmaximaliserende producenten reeds ontwikkelde mogelijkheden niet altijd gebruiken. Het economische plafond ligt daarom altijd ver onder het technische plafond. Een goed beleid kan de afstand tussen beide verminderen, maar niet wegnemen.

Toenemende vraag naar voedsel en diervoeder

Als we uitgaan van een groei van de wereldbevolking van 6,5 naar 9 miljard in 2050, een veranderend eetpatroon en een calorisch rijker dieet voor mensen uit ontwikkelingslanden, dan hebben we in 2050 mondiaal de dubbele hoeveelheid biomassa voor voedsel en veevoer nodig ten opzichte van nu. Ook de FAO hanteert dat getal. Deze dubbele hoeveelheid voedsel moet allemaal geteeld kunnen worden, terwijl er ook een groeiende behoefte bestaat aan biomassa voor andere levensbehoeften, zoals energie (warmte en brandstof), kleding, hout voor huizen, papier, medicijnen en chemicaliën.

De omvang van de wereldproductie van voedingsgewassen in het jaar 2000 was volgens de *FAOSTAT Food Balance Sheets* ongeveer 3.220 miljoen tonne aan graanequivalenten. Hiervan wordt de helft gebruikt voor directe consumptie door mensen. De totale plantaardige productie van voedselgewassen wordt gerealiseerd op ongeveer 1.500 miljoen ha. Behalve land is water vaak een beperkende factor. Volgens de FAO wordt wereldwijd 18% (270 miljoen ha) van het landbouwareaal geïrrigeerd; het geïrrigeerde land levert 40% van de wereldvoedselproductie.

Toenemende vraag naar niet-voedseltoepassingen

Een aantal niet-voedselgewassen heeft ook grond nodig. Op dit moment wordt ruim 2% van het landbouwareaal gebruikt voor energiegewassen. Uitgaande van een gemiddelde energieopbrengst van 100 GJ/ha dekt dit circa 0,5% van de wereldbehoefte aan energie. Dit extrapolerend zou het totale landbouwareaal maximaal 25% van de wereldenergiebehoefte kunnen dekken onder de huidige technologische randvoorwaarden. Ter vergelijking: een klassiek *non-food* gewas als katoen beslaat 2,35% van het totale landbouwareaal op de wereld. Dit is een totaal andere orde van grootte dan de areaalbehoefte voor energiegewassen wanneer deze in een aanzienlijk deel van de totale energiebehoeften zouden moeten voorzien.

Het toekomstige ruimtebeslag voor energiegewassen is omgeven met veel onzekerheden in de aannames over gewastype, teeltsystemen, gebruik van restproducten, energietechnologie, beschikbaar land en water, het aandeel van biomassa-import en de realiteitswaarde van scenario's over energieconsumptie. De Europese Commissie en de EU-lidstaten hebben afgesproken dat in 2020 10% van alle transportbrandstof uit biomassa moet worden gehaald. Als al de daarvoor benodigde biomassa binnen Europa wordt geteeld en de huidige 1e-generatietechnologie wordt toegepast, is daarvoor 20 tot 30 miljoen ha nodig ofwel 20-30% van het huidige akkerland in de EU27. Op wereldschaal betekent de Europese bijmengingspolitiek een beslag op 19% van de mondiale productie van plantaardige oliën ter vervanging van 10% diesel en op 2,5% van de wereldgraanproductie ter vervanging van 10% benzine (De Santi et al., 2008). Deze berekeningen laten zien dat bijmenging zeer forse gevolgen kan hebben voor het landgebruik.

Brehmer (2008) kiest een andere benadering. Hij gaat uit van een concept waarbij volgens het *biorefinery*- concept gewassen voor meer dan één doel worden gebruikt. De energiewinst wordt in dat geval bepaald door enerzijds de directe energieopbrengst uit restanten van gewassen en anderzijds door besparingen die behaald worden door het gebruik van de biomassa als leverancier van chemische grondstoffen. Uitgaande van opbrengsten onder *best practice* teelttechnieken, met gewasopbrengsten die ruwweg 60% boven het gemiddelde liggen en het gebruik van de hele plant, komt Brehmer voor een reeks van 16 gewassen uit op een energiewinst tussen de 125 en 721 GJ/ha. Dat is aanzienlijk hoger dan het huidige gemiddelde (100 GJ/ha) en toont aan dat *biorefinery*-concepten perspectief bieden.

Tenzij er een versnelde areaaluitbreiding van landbouwgrond gaat optreden, zal een sterke toename van het areaal dat specifiek geteeld wordt voor eerste of 2e-generatie-energiegewassen grotendeels ten koste gaan van het areaal voor de bestaande landbouwproductie. De groei in ruimtebeslag kan beperkt blijven door het inzetten van reststromen voor energieopwekking. Overigens geldt ook hier dat realisatie van het technische potentieel en de mogelijke omvang van de toepassingen specifiek beleid en grote investeringen vergen.

1.2 Uitbreiding van het landbouwareaal

De vraag is hoeveel grond de wereld nog extra beschikbaar heeft boven de huidige 1.500 miljoen ha om in te zetten voor de productie van gewassen.

Over de periode 1970-2000 is het akkerbouwareaal toegenomen met gemiddeld 5 miljoen ha per jaar. Dat is een groei van 0,33% per jaar, dus ongeveer 10% in 30 jaar. Tegenover de uitbreiding van het landbouwareaal staat de ontbossing, die wordt geschat op 9 miljoen ha per jaar. Dat is dus bijna twee keer zo veel als de landbouwexpansie. De overige 4 miljoen ha komt voor rekening van de omzetting van bos in stedelijk gebied en in extensief grasland.

Het areaal dat de wereld nog in reserve heeft om de landbouwproductie uit te breiden, kan worden geschat op basis van klimaat- en bodemomstandigheden. Dit was onderdeel van de eerste Wageningse studie naar de maximale wereldvoedselproductie (Buringh et al., 1975). Zij schatten in die tijd de omvang van alle geschikte grond op 3.419 miljoen ha. Het gehanteerde potentiële gebruik had grotendeels betrekking op regenafhankelijke landbouw (2.950 miljoen ha), naast 470 miljoen ha geïrrigeerde landbouw. Beide areaalschattingen waren aanzienlijk hoger dan de toen gebruikte arealen (1.200 miljoen ha zonder en 200 miljoen ha met irrigatie).

Een andere gedetailleerde studie naar het potentiële landbouwareaal is de GAEZ-studie van IIASA en FAO (Fischer et al., 2001). Die studie toont aan dat slechts 470 miljoen ha land zonder beperkingen geschikt is voor regenafhankelijke landbouw. Maar landbouw kan ook plaatsvinden op gronden met geringe of matige beperkingen. Daarvan heeft de wereld 2.460 miljoen ha ter beschikking, waarvan een flink deel nog niet in cultuur is genomen. In totaal zou het potentieel bebouwbare areaal bijna 3.000 miljoen ha zijn, tweemaal zo veel als het huidige areaal. Dat komt in grote lijnen overeen met de schattingen van Buringh. De geschiktheid van gronden voor landbouw hangt verder nog af van gewaskeuze en inputniveau. Slechts 2.000 miljoen ha grond van redelijk goede kwaliteit is geschikt voor intensief gebruik. Als we daarvan bestaand bos plus de bekende natuurgebieden aftrekken en rekening houden met het huidige stedelijk ruimtebeslag, dan is er ongeveer 1.500 miljoen ha vrij goede grond voor landbouw zonder irrigatie. Dit laatste ligt in de buurt van het huidige wereldareaal. Hierop kunnen afhankelijk van het klimaat een tot drie gewassen per jaar worden verbouwd. Het areaal en het opbrengstniveau kunnen verder worden verhoogd met irrigatie. De GAEZ-studie schat dat door uitbreiding van irrigatie ongeveer 200 miljoen ha extra in cultuur genomen kan worden. De invoering van supplementaire irrigatie op het regenafhankelijke areaal wordt in de GAEZ-studie niet verder uitgewerkt.

Als we onze bossen en natuurgebieden willen ontzien betekent bovenstaande dat areaaluitbreiding over het algemeen zal plaatsvinden op gronden met beperkingen, waarop het meer moeite kost om hoge producties te realiseren en die kwetsbaarder zijn voor degradatie. Maar er zijn grote verschillen tussen de wereldregio's. Volgens de GAEZ-studie liggen de grootste expansiemogelijkheden voor regenafhankelijke landbouw in Zuid-Amerika en Afrika, terwijl in Azië de mogelijkheden beperkt zijn (de rol van irrigatie blijft hier buiten beschouwing). In de gematigde klimaatzone (Europa, Noord-Amerika en Rusland) zou er geen ruimte meer zijn voor expansie voor intensieve landbouw, maar nog wel voor minder intensieve landbouw - met uiteraard minder opbrengst. De GAEZ-studie toont verder aan dat in de droge gebieden van met name Centraal en West-Azië, Zuidelijk Afrika, Noord-Afrika en Australië irrigatie tot fors hogere producties kan leiden. De realisatie daarvan hangt echter sterk af van de hoeveelheid beschikbaar water per stroomgebied. De GAEZ-studie besteedt daar geen aandacht aan. Dit is wel in een eerdere studie van Luyten (1995) aan de orde gekomen. Volgens Luyten omvat de wereld 4.818 miljoen ha grond die geschikt is voor akkerbouw en nog eens 2.990 miljoen ha die gebruikt kan worden voor extensieve beweiding. Dit is veel hoger dan de bovenstaande schattingen van Buringh en Fischer. Luyten gaat dan ook uit van het in gebruik nemen van al het geschikte land dat nu nog bebost is en extensieve veeteelt op het overige land waar het maar kan.

De studie van Luyten houdt expliciet rekening met de beschikbaarheid van irrigatiewater per stroomgebied en de efficiency van de waterbenutting in kilo's bijgroei per eenheid water. De gehanteerde modellen gaan uit van een maximale (potentiële) productie en een vertienvoudiging van het geïrrigeerde areaal. Het scenario houdt in dat de bodems een voldoende voorraad fosfaat moeten bevatten om de gewenste hoge productieniveaus blijvend te kunnen realiseren. De schattingen van Luyten zijn (te) hoog. Zo schatten Penning de Vries et al. (1995) dat ongeveer de hele bekende wereldvoorraad van winbaar rotsfosfaat (rond 8 miljard tonne) nodig is om aan de fosfaatbehoefte zoals geformuleerd door Luyten te voldoen. Daarnaast krijgt landbouw voorrang op bossen en sneuvelen er daarom in het scenario van Luyten veel bossen voor de uitbreiding van landbouwgronden. Ook is niet duidelijk rekening gehouden met de beperking aan het akkerbouwareaal als gevolg van bebouwing en infrastructuur, die in totaal wel 10% van het geschikte landbouwareaal kunnen beslaan. Al met al overschat de studie de omvang van het geschikte areaal.

Koning et al. (2008) hebben Luytens schatting van de beschikbare arealen bijgesteld door uit te gaan van een iets kleiner beschikbaar areaal (7.600 miljoen ha voor akkerbouw en weidegebieden) en rekening te houden met een groei van het geïrrigeerde areaal met 50%, van 200 tot 300 miljoen ha. Ook wordt rekening gehouden met de toekomstige ruimtebehoefte voor steden, bos en natuur, en voor niet-voedselgewassen. Dit ruimtebeslag concurreert met de verbouw van voedselgewassen en vermindert derhalve de grond die ingezet kan worden voor voedselproductie. De auteurs nemen aan dat het beschikbare areaal voor voedselproductie daardoor met 20 tot 43% afneemt. Het areaal dat overblijft voor voedselproductie ligt dan tussen de 1.500 en 2.800 miljoen ha voor akkerbouw en tussen de 2.800 en 3.300 miljoen ha voor begrazing (zie tabel 1.1).

Tabel 1.1 **Schatting van het huidige en potentiële mondiale landbouwareaal (in giga-ha)**

	Buringh (1975)	Luyten (1994)	Fisher et al.(2001)	Koning et al.(2008)
Huidige grondgebruik				
Akkerbouw	1,4	1,5	1,5	1,5
Regenafhankelijk areaal	1,2	1,3	1,3	1,3
Geïrrigeerd areaal	0,2	0,2	0,2	0,2
Areaal voor extensieve begrazing				2,8
Potentieel grondgebruik				
Akkerbouw	3,4	4,8	2,9	1,5-2,8 a)
Regenafhankelijk areaal	2,9	2,3	2,7	1,2-2,5
Geïrrigeerd areaal	0,47	2,4	0,2	0,3
Areaal voor extensieve begrazing		3,0		2,8-3,3

a) De minima en maxima zijn de geschatte onder- en bovengrenzen op basis van verwachte claims op grond voor niet-productiegerichte doeleinden.

De bovenstaande schattingen van de beschikbare areaalreserve suggereren in eerste instantie een enorm groeipotentieel voor de wereldlandbouwproductie. Zodra echter rekening gehouden wordt met een aantal negatieve effecten (verlies van bos, geen leefruimte, geen ruimte voor herbeplanting van bos voor het Kyoto-klimaatverdrag, geen ruimte voor energiegewassen) of met inherente beperkingen (waterverdeling, beschikbare hoeveelheid water, fosforvoorraad, nutriëntenefficiëntie) wordt het onwaarschijnlijk dat de meest optimistische areaaluitbreidingen uit de geschetste scenario's gerealiseerd kunnen worden. Daar komt nog bij dat door degradatie ook landbouwgrond aan de productie onttrokken wordt. Het meest realistische scenario lijkt een stabilisering of hooguit lichte groei van de beschikbare gronden, conform de ontwikkelingen van de afgelopen decennia. Maar zelfs als er onder druk van een stijging van de vraag een versnelde expansie van het landbouwareaal plaatsvindt, dan nog zal de groei van de productie vooral moeten komen uit intensivering, waarbij wellicht wel het aandeel van irrigatie nog verder kan toenemen.

1.3 Verhoging van de landbouwproductie

Om bij een gelijkblijvend landbouwareaal meer te produceren zal de productie per hectare omhoog moeten. Het verleden heeft spectaculaire stijgingen in die productie laten zien, maar uiteraard is dat geen garantie voor de toekomst. De agro-ecologische principes helpen ons een beeld van de mogelijkheden te krijgen. Die principes gaan uit van een theoretisch maximaal haalbare productie, uitgaande van zonlicht, temperatuur, CO_2 en planteigenschappen. De theoretisch maximale productie wordt vervolgens begrensd door beperkende factoren zoals water en meststoffen, en verder gereduceerd door factoren als ziektes, plagen en (ozon)vervuiling.

In Wageningen zijn in het verleden een aantal productiestudies uitgevoerd, gebaseerd op deze principes. Recent zijn de data geactualiseerd en beschreven in de notitie *Long-term global availability of food: continued abundance or new scarcity* (Koning et al., 2008). Als vertrekpunt nemen de auteurs de eerdere studie van Luyten (1995). Volgens deze zou de wereldlandbouw 72 gigatonne aan graanequivalenten kunnen produceren als alle voor akkerbouw of veeteelt geschikte grond gebruikt werd en de theoretische maximumopbrengsten werden gehaald. Daarmee zouden 47 miljard mensen van een overvloedig dieet kunnen worden voorzien. Volgens de auteurs is dit niet realistisch. Om te beginnen zal niet al het geschikte areaal voor voedselproductie gebruikt kunnen worden (zie boven). Daarnaast zullen bovengenoemde beperkende en reducerende factoren de theoretische maximumopbrengsten onbereikbaar maken. Koning et al. (2008) gaan uit van een onvermijdelijke *yield gap* van 20%. Ook nemen ze aan dat een consumentenverlies van 20% niet is te voorkomen. Op die manier komen ze aan een bijgesteld technisch potentieel van 32 tot 47 gigatonne aan graanequivalenten, waarmee 16 tot 24 miljard mensen rijkelijk gevoed kunnen worden.

Daarnaast waarschuwen de auteurs ervoor dat de feitelijk haalbare productie niet alleen afhangt van de biofysische mogelijkheden, maar ook van sociaal-economische wetmatigheden. Zo zullen producenten niet zozeer streven naar de maximalisatie van de productie, maar naar maximalisatie van *return-to-investment*. Afnemende meeropbrengsten zullen ertoe leiden dat uitbreiding van het irrigatieareaal ver zal achterblijven bij wat puur technisch gezien mogelijk is. De prijsverhoudingen tussen inputs en outputs leiden er toe dat sommige technieken niet ontwikkeld worden, temeer omdat de energie- en fosfaatprijzen zullen stijgen. Bovendien hebben de prijsverhoudingen tot gevolg dat boeren sommige technieken die wél ontwikkeld zijn, níet gebruiken. Dit laatste kan vooral invloed hebben in gebieden met grotere risico's of een zwakke infrastructuur. Onder dat soort omstandigheden kan het economisch efficiënt zijn om vast te houden aan simpele technieken, die echter een lagere opbrengst geven per hectare. Dit geldt voor Latijns-Amerika en Afrika ten zuiden van de Sahara, waar naar schatting de helft van de mondiale reservecapaciteit voor voedselproductie ligt. De invloed die dit soort factoren op de toekomstige voedselproductie zullen hebben is nauwelijks te kwantificeren. Om de gedachten te bepalen presenteren de auteurs een scenario waarbij het mondiale irrigatieareaal groeit met 50%, terwijl de *yield gap* in de ontwikkelde regio's en delen van Azië afneemt tot 25%, maar in de ex-Sovjet Unie, Latijns-Amerika en Afrika slechts tot respectievelijk 40%, 60% en 80%. Bij zo'n *business as usual*-scenario is de productie in 2050 slechts voldoende om 8 tot 10 miljard mensen rijkelijk te voeden.

De IIASA (International Institute for Applied Systems Analysis) en FAO komen tot vergelijkbare conclusies. Volgens FAO-stat wordt wereldwijd gemiddeld 3,2 tonne graan per hectare geproduceerd. Ter vergelijking: in Nederland halen we 8,1 tonne per hectare, in West-Europa en Noord-Amerika 6,5 tonne per hectare, in ontwikkelingslanden 2,9 tonne per hectare en in de minst ontwikkelde landen (*least developed countries*) 1,8 tonne per hectare. Volgens IIASA is duurzaam een gemiddelde productie van 5,4 tonne per hectare mogelijk. Daarbij gaat IIASA uit van regenafhankelijke landbouw, zonder rekening te houden met de mogelijkheden van uitbreiding van het geïrrigeerde landbouwareaal, dit in tegenstelling tot de Wageningse studie.

Beide studies suggereren dat grofweg een verdubbeling van de voedselproductie mogelijk moet zijn, maar dat dit niet vanzelf zal gaan. De productie zou verder beperkt kunnen worden door een mogelijk tekort aan fosfaat waar sommigen voor waarschuwen. Beide studies tonen ook aan dat er weinig marge is en dat ingrijpende verschuivingen van bijvoorbeeld *food*- naar *non-food*-productie grote gevolgen voor de voedselzekerheid kunnen hebben. De verwachting is dat in de toekomst een flink deel van Europa's biomassa zal worden geïmporteerd. De invoering van nieuwe op de wereldmarkt gerichte teelten in ontwikkelingslanden kan ook gemakkelijk leiden tot sociale ontwrichting, doordat buitenlandse cultuurmaatschappijen land of landgebruiksrechten opkopen.

We concludeerden al dat er nauwelijks ruimte is voor uitbreiding van het wereldareaal aan landbouwgrond inclusief grasland, afgezien van de mogelijkheid het geïrrigeerde areaal te vergroten. Onder de heersende sociaaleconomische omstandigheden en trends kan de wereldlandbouwproductie in 2050 maar net aan voldoende zijn om de verwachte 9 miljard mensen rijkelijk te voeden. Dat was immers de voedselzekerheidsdoelstelling. Hoewel het er met andere aannames op lijkt dat er veel meer biomassa beschikbaar kan komen voor andere doeleinden, waaronder biomassa voor energie, moeten we daar toch kritisch naar kijken. Deze aannames kunnen worden samengevat met simpele slogans zoals minder mensen op de wereld, eet minder vlees, verspil minder voedsel, voer de varkens minder eiwit, enzovoorts. Ook energiebesparing kan de druk op de vraag naar biomassa verminderen. En ten slotte kunnen we ook anticiperen op sociaal-economische revoluties en trendbreuken om de *yield gaps* te verkleinen. We volstaan hier met de constatering dat onder de huidige omstandigheden de gewenste productieverhoging niet bereikt zal worden. Daarvoor zijn grote veranderingen nodig op sociaaleconomisch en technologisch gebied. Bij een sterk stijgende vraag naar *non-food*-producten zullen nieuwe, innovatieve wegen gezocht moeten worden om efficiënter te produceren en onze voedselproductie zeker te stellen. De realisatie hiervan vereist wel nieuw beleid en hoge investeringen in onderzoek en ontwikkeling. In de volgende paragraaf verkennen we een aantal wegen om meer biomassa te produceren, waarbij we enkel ingaan op de technologische aspecten.

1.4 Verhoging van de efficiëntie van het gebruik van plantaardige grondstoffen en van schaarse inputfactoren als water, mineralen en grond

Optimaal gebruik van schaarse inputfactoren

Optimale productie is een teeltstrategie die erop is gericht de *yield gap* te verkleinen en is gebaat bij een intensieve teelt. Intensivering bespaart niet alleen goede landbouwgrond, maar zorgt tevens voor een optimale benutting van schaarse inputfactoren zoals mineralen, water en apparatuur. Bij een optimaal landgebruik hoort een keuze van gewassen met optimale groei onder de gegeven omstandigheden. Idealiter hebben de gewassen een optimale samenstelling voor gebruik als voedsel, chemie, transportbrandstof en andere levensbehoeften zoals energie (warmte & brandstof), kleding, hout voor huizen en papier, medicijnen, en biochemicaliën. Veredeling zal daarbij een belangrijke rol spelen. De veredeling moet zich dan niet alleen richten op het gewenste voedsel, maar ook op *non-food*-componenten, een betere verwerkbaarheid, een betere seizoensonafhankelijkheid en betere transportmogelijkheden. Daardoor kan de duurzaamheid, maar zeker ook de economische waarde per hectare enorm toenemen.

Genetisch gemodificeerde gewassen

Biotechnologie biedt vele nieuwe mogelijkheden om nieuwe gewassen te ontwikkelen met een hoger productiepotentieel per hectare. Een krachtige, maar tegelijk omstreden techniek maakt gebruik van genetische modificatie. Genen worden direct ingebracht in het DNA van een plant, met als doel specifiek één eigenschap aan die plant toe te voegen. Die techniek heeft geleid tot vele genetisch gemodificeerde gewassen (GMO's), die zeer gevarieerde en agronomisch interessante eigenschappen erbij hebben gekregen. De kracht van de techniek is tegelijk de achilleshiel: hoe hou je deze technieken beheersbaar en voorkom je grote negatieve ecologische effecten. Deze discussie leidt tot grote maatschappelijke controverses. Desondanks zet de techniek zijn opmars voort. De jaarlijkse overzichten van Clive James (2008) tonen al jaren lang een lineaire groei van de oppervlakte die bebouwd is met GMO's. De agronomische voordelen zijn dusdanig dat de techniek in grote delen van de wereld omarmd wordt. Meer dan 10 miljoen boeren bebouwden in 2008 samen meer dan 140 miljoen ha met GMO's. De techniek is er en zal blijven. Risico's dienen echter niet gebagatelliseerd te worden. Soortgrenzen kunnen worden overbrugd en 'ontsnapte' genen kunnen grote effecten op ecosystemen hebben. Goede risicoschattingen zijn dan ook onontbeerlijk. Het is daarom noodzakelijk de ontwikkelingen goed te volgen en in de aangewezen gremia de ontwikkelingen mede te sturen. Een bot taboe op GMO's is onverstandig en contraproductief.

Ondanks het hoge tempo waarin deze gewassen de wereld veroveren, zijn GMO's geen panacee voor de wereldvoedselvoorziening. De wereldvoedselvoorziening hangt primair af van de mogelijkheden om te sturen op de effecten van opbrengstbepalende factoren, zoals water, ziekten, plagen en onkruiden. Dat vergt een goed management dat optimaal gebruik maakt van alle mogelijkheden. Biotechnologische inzichten en instrumenten moeten echter wel een rol kunnen spelen ten bate van de ontwikkeling van de landbouw in ontwikkelingslanden. Niet omdat ze de garantie kunnen geven dat daarmee voldoende voedsel wordt geproduceerd, wel omdat ze een nuttig en goed hulpmiddel (instrument) kunnen zijn bij het oplossen van een aantal hardnekkige problemen, zoals het verkleinen van de *yield gaps* in ontwikkelingslanden.

Bioraffinage, kaf én koren

Een verdere opbrengstverhoging ten behoeve van *food-* en *non-food-*toepassingen kan bereikt worden door na de oogst niet slechts een deel, maar alle delen van de plant te benutten. Een ander woord hiervoor is bioraffinage. Dit is een verzameling van biochemische en fysische scheidingstechnologieën, waarmee allerlei verschillende planten(residuen) in zekere mate in componenten kunnen worden opgesplitst. Deze technologieën bieden de mogelijkheid om componenten die niet nodig of zelfs nadelig zijn voor een bepaalde toepassing, in te zetten voor een geheel andere toepassing waarvoor dan geen aparte grondstof meer nodig is. Als we bijvoorbeeld plantmateriaal willen toepassen zijn we momenteel alleen geïnteresseerd in componenten zoals zetmeel en andere suikers of plantenoliën, die we gebruiken voor voedsel, voeder, cosmetica en transportbrandstof zoals bioethanol en biodiesel. Andere componenten van de plant zoals de stengel en het zogenaamde kaf van het koren kunnen echter ook nuttig gebruikt worden. Zo wordt veel verwacht van de suikers die in de lignocellulose van de plant zitten. Hier kunnen mogelijk binnen enkele jaren met 2e-generatietechnologie biobrandstoffen en chemicaliën van gemaakt worden. Naast suikers of olie bevatten planten ook andere componenten, zoals eiwitten die gebruikt kunnen worden voor humane of dierlijke voeding. Deze eiwitten zijn opgebouwd uit een twintigtal aminozuren, die op hun beurt ook weer op te splitsen zijn voor voeding of veevoeder en de productie van bulkchemicaliën. Deze verdere verwerking kan gebeuren op basis van de specifieke moleculaire structuur van bepaalde aminozuren. Op deze manier kunnen we een flinke hoeveelheid energie besparen, die anders nodig was om de bijzondere bouwstenen synthetisch te fabriceren.

Er zijn veel van deze bioraffinage voorbeelden denkbaar en in ontwikkeling, waarbij *food-* en *non-food*-toepassingen elkaar versterken. Zo kan de productie van voeding wezenlijk efficiënter worden door een deel van de plant tot voedsel te verwerken en een ander deel te gebruiken als *non-food crop* gericht op de productie van onder meer *chemical building blocks*. Ook gras kan beter benut worden. Gras bevat meer eiwitten dan voor de voeding van dieren nodig is. De overmaat aan eiwitten kan eruit gewonnen worden voor gebruik als *non-food*-grondstof en de rest als veevoer. Kleinschalige bioraffinage heeft als voordeel dat met name de nutriënten zonder kosten kunnen worden gerecycled, omdat de in water opgeloste nutriënten niet hoeven te worden geconcentreerd alvorens te kunnen worden getransporteerd.

Ook het gebruik van biomassa voor energieopwekking kan geoptimaliseerd worden. Een aanzienlijk gebruik van biomassa voor energiegewassen en met name de bijmenging bij transportbrandstoffen, zal extra druk op onze productiesystemen geven. Focus op reststromen voor energieopwekking vermindert die druk. Maar voor het optimale gebruik van biomassa moet verder gekeken worden dan naar het gebruik als transportbrandstof. Een hogere toegevoegde waarde van biomassa is mogelijk als de biomassa als grondstof in de industrie verwerkt wordt tot hoogwaardige producten, waaronder ook brandstof. Optimaal gebruik van biomassa betekent een hoge vervanging van fossiele brandstof, wat wordt bereikt wanneer de biomassa efficiënt is geproduceerd en conversie van biomassa in chemische producten effectief is en toegesneden op de natuurlijke chemische functionaliteit in de biomassa. Een hoge toegevoegde waarde voor biomassa als chemische grondstof versterkt echter weer wel de competitie met voedseltoepassingen.

Benutten van de zee
Een andere optie voor de voedsel en *non-food*-productie is de *off-land*-productie. Als we er in slagen in een mariene omgeving op grote schaal bijvoorbeeld algen te kweken voor *food-* of *non-food*-toepassingen, wordt een enorm nieuw potentieel aangeboord zonder dat we beslag leggen op (goede) landbouwgrond. Bijkomend voordeel kan zijn dat op deze manier via *fyto-mining* een deel van de uitgespoelde fosfaten herwonnen kan worden, maar ook dat de grote hoeveelheid vocht die zich in algen ophoopt geschikt gemaakt kan worden als irrigatiewater voor bepaalde vormen van landbouw.

Beter benutten van de fotosynthese
Slechts een klein deel van het opvallend licht wordt door planten ten slotte omgezet in biomassa. Door de efficiëntie van de fotosynthese te verhogen neemt de potentiële productie per hectare toe. Daardoor kunnen productiegrenzen verder verlegd worden. Verder in de tijd ligt de mogelijkheid om op basis van de fotosyntheseprincipes uit de natuur direct zonlicht om te zetten in transportbrandstof of elektrische stroom, zonder dat we hele planten moeten maken. Hierdoor kunnen we enorm vooruitgaan in de efficiëntie van het invangen van de energie uit zonlicht.

1.5 Conclusie

De gestaag toenemende vraag naar landbouwproducten voor voedsel en veevoer in combinatie met de verwachting dat de vraag naar non-food-gewassen nog veel sneller zal stijgen vereist een enorme productieverhoging. Deze zal grotendeels moeten worden opgevangen door productiviteitsstijging per hectare en door efficiënter gebruik van de landbouwproducten. Op wereldschaal is uitbreiding van het landbouwareaal slechts beperkt mogelijk. Wel kan met uitbreiding en vernieuwing van irrigatiesystemen nog relatief veel gewonnen worden.

Veel aandacht is nodig voor hergebruik van grondstoffen en reststromen en voor vergroting van de nutriëntenefficiëntie. De realisatie van technische verbeteringen in de landbouw vergt ook institutionele aanpassingen, maar doorgaans is een volledige benutting van alle theoretische productiviteitsverbeteringen niet haalbaar.

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2 Wanted: institutions for balancing global food and energy markets

Niek Koning and Arthur P.J. Mol

2.1 Introduction

Food prices have major effects on food security. High prices make food inaccessible for poor consumers. Low and unstable prices hamper investment that should increase employment and moderate the cost of food production in poor countries. Since the late 19th century, international agricultural prices have fluctuated downwards. As a reaction, many countries have stabilised and/or supported their domestic agricultural prices. In most of them, rapid agricultural development contributed to overall growth, reducing poverty and food insecurity (Koning, 2007; for Asian Green Revolution countries, see Dorward et al., 2004). Conversely, poor countries that failed to stabilise and/or support farm prices have seen their agriculture stagnate. The plight of farmers was exacerbated by over-taxation and dumping practices of countries that failed to combine farm income supports with an adequate management of their supply. Agricultural stagnation dragged the rest of the economy with it, leaving large parts of the population poor and vulnerable to fluctuations in food prices.

After several decades with very low prices, the year 2008 saw a sudden spike in global food prices. Although prices have meanwhile come down again, this has rekindled concerns that the long-term decline in food prices might give way to increased scarcity. Population growth and an increasing consumption of livestock products may double the global demand for biomass for food up to mid-century. Whether the global supply will keep pace with this is uncertain (Koning et al., 2008; Rosegrant et al., 2006). One important reason for this is the competition from agro-fuels (crop-based biofuels). The production of these has strongly increased after 2000. At first, this was seen as a possibility to improve farm prices that had become too low to get agriculture in poor countries moving. However, the role of the agro-fuel boom in the 2008 price spike made clear that agro-fuels might also exacerbate food price instability and make food prices prohibitive for the poor (Banse et al., 2008a; Mitchell, 2008; Rosegrant, 2008).

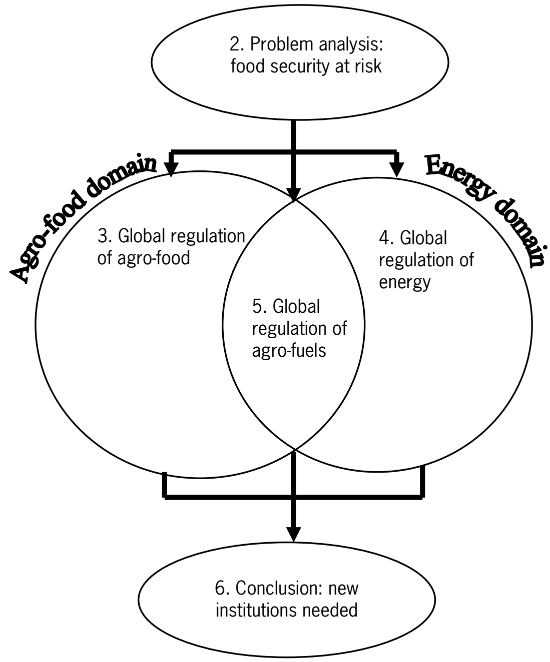
To be sure, various strategies may moderate the risks that the evolution of agro-food markets involves for global food security. On the supply side, there are many possibilities for raising food production in developing countries (cf. InterAcademy Council, 2004; World Bank, 2007). More generally, there remains considerable room for increasing the global supply of food through sustainable yield increases, bio-refinement and new non-farm biomass production systems. On the demand side, an increase in food scarcity can be countered by policies that mitigate the increase in consumption. Most importantly, effective poverty reduction could moderate the growth of world population and the ensuing increase in demand. After all, poverty is the main factor that is holding back the decline in demographic fertility in many low-income countries. In addition, the growing consumption of livestock products that involve especially unfavourable feed conversion ratios, such as feedlot beef, could be mitigated. The development of effective meat substitutes is a possibility, but a shift to poultry or herbivore fish would also help (Koning et al., 2008).

Also with respect to biofuels, various options are available for protecting the food security of the poor. Governments could stop supporting first-generation agro-fuels, and channel the development of bio-based non-foods towards feedstocks that minimally compete with food (e.g. waste, algae). At the same time, small-scale techniques for the decentralized pre-processing of biomass could be developed to allow small farmers to benefit from the growth in bio-based non-foods (Sanders et al., 2007).

However, a key condition for steering global food security safely through the storms is stable international agricultural prices. These should be high enough to stimulate agricultural development in poor countries and timely investment in global capacities for food production. At the same, they should not be too high to allow sufficient access to food for poor consumers. In this respect, the rapid growth of agro-fuels poses a major challenge. Through them, food markets become closely related to energy markets, not just nationally but globally. This paper analyses which institutions are available, or missing but needed, for balancing food and energy markets with a view to safeguarding the food security of the world's poor.

The outline of the paper is presented in Figure 2.1. We start with a more detailed discussion of the food security risks that follow from price movements in agro-food markets, paying special attention to effects of the emerging market for biofuel (Section 2.2). Then we survey the institutions for market regulation that currently exist in three markets. First, we review how the regulation of agricultural markets has evolved over time (Section 2.3). Second, we consider the regulation of fossil fuel energy markets (Section 2.4). And third, we review current developments in the regulation of the emerging markets for biofuels, which connect both preceding domains (Section 2.5). Section 2.6 concludes by indicating institutional solutions for balancing these various markets so as to safeguard global food security.

Figure 2.1 Structure of the paper



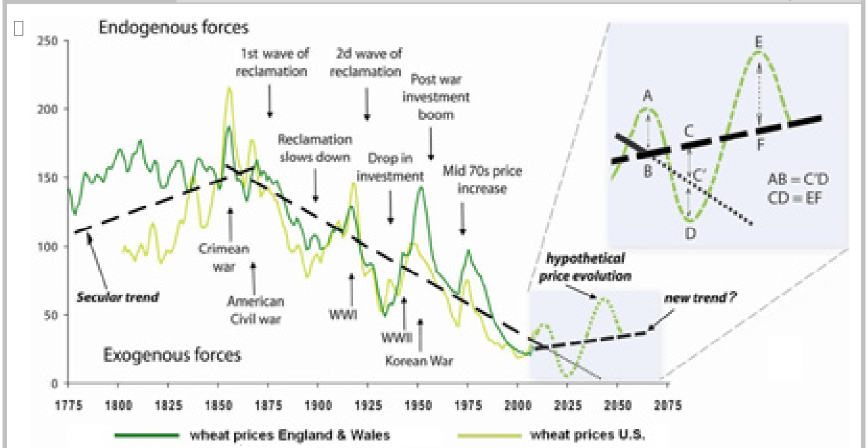
2.2 Food security at risk

Evolution of agricultural prices in the 20th century

Agricultural markets are prone to strong price instability. On the one hand, the demand and the short-term supply are price-inelastic. This implies that small surpluses cause steep price falls, while small shortages send prices skyrocketing. On the other hand, environmental and general-economic turbulence makes fluctuations in supply and demand volumes unavoidable. These conditions together cause strong fluctuations in prices. In addition, myopic expectations cause endogenous price fluctuations (Ezekiel, 1938; Nerlove, 1958). Such 'cobweb cycles' are well-known in regional pig markets ('pig cycle'). However, they also operate in wider agricultural markets (Díaz Jerónimo, 2006; also cf.

Boussard et al., 2006). By way of illustration, Figure 2.2 shows the long-term evolution of wheat prices in Britain and the US, as proxies for world market prices. The historical evolution (see graphs until 2007) shows strong fluctuations, which were caused by the interaction of exogenous shocks (in particular, major wars) and endogenous mechanisms.

Figure 2.2 **Indexes of real wheat prices in the US and England and Wales, 1800-2007, and hypothetical evolution after 2007. (Prices up to 2005 are 5-year moving averages, with 1901-05 = 100.) Prices in 2005-07 are annual prices with the same base years.**



Source: Mitchell 1975, 1990, 1993; USBC 1976; Eurostat various years; OECD 1990; USDA 2008; USBL 2008.

Figure 2.2 also shows that decadal price fluctuations were movements along a longer-term trend. Before the Industrial Revolution, population growth sent the trend upwards. Scarcity of fertiliser restricted the increase in yields, high transport costs made it costly to supplement local deficits through imports, and under-developed knowledge infrastructures slowed technical progress. Around 1875, these Malthusian constraints were broken. New fertilisers, the Transport Revolution, and scientific research removed the shackles on supply, while fossil fuels freed vast areas of land that had until then been used for non-food crops (Schultz, 1945). Since then, agricultural prices have fluctuated along a downward trend. The latter did not just reflect a normal cost price that decreased over time by productivity growth. Agricultural markets rather leaned towards price-depressing overproduction. This was because farmers responded to low earnings by tightening their belts and investing in new techniques that increased production (Cochrane, 1959). In a free market, therefore, supply and demand were only balanced when low prices squeezed the margins that farmers had for investment. It meant that equilibrium was achieved through a slowdown of innovation rather than through a reallocation of labour and capital (Bairoch, 1976; Koning, 1994). A striking example was the near-total stagnation of productivity growth in the agriculture of Britain between 1875 and 1930, when this country kept to agricultural free trade in spite of falling world market prices (Koning, 1994; Van Zanden, 1991; Wade, 1981).

New scarcity?

That food prices declined in the 20th century does not guarantee that they will decline in the future. Since the late 1960s, neo-Malthusian authors have been warning for a new impending food scarcity (Brown, 1995; Ehrlich, 1968; Meadows et al., 1972). Economists in established research institutions long contradicted these predictions (Bruinsma, 2003; Mitchell et al., 1997; Rosegrant et al., 2001). Recently, however, some of them have become more cautious in assessing the global availability of food in the future (e.g. Rosegrant et al., 2006).

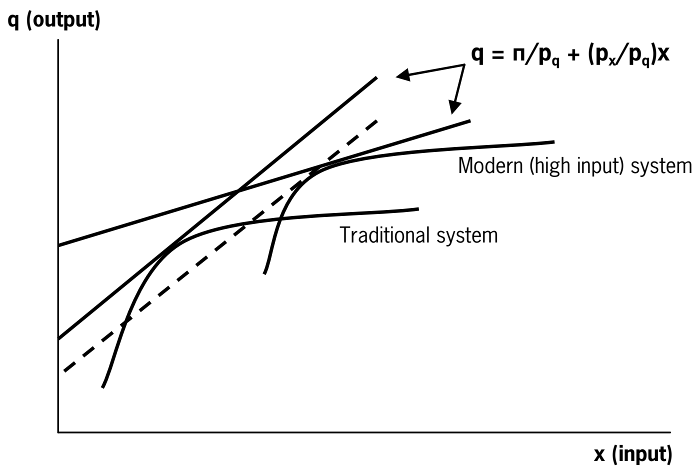
Between now and mid-century, the world population will increase from 6.5 billion to around 9 billion people. The demand for animal products may double, not least as a result of rising incomes in successful developing countries (Keyzer et al., 2005; Steinfeld et al., 2006). As a consequence, the global demand for biomass for food and feed may more than double. This expected demand growth is not as large as that experienced in the second half of the 20th century, when a rapid response of the global supply still caused international agricultural prices to decrease. Therefore, the real question is whether the global supply of food will once more be able to keep up with the increase in demand.

This question can only be tentatively answered. On the one hand, we know that the main sources of agricultural growth in the 20th century are drying up. Only Africa and Latin America have significant reserves of suitable land. In several grain belts, freshwater supply for irrigation is running dry (Molden, 2007; Rosegrant et al., 2002). And the increase in yield potentials of major food crops is increasingly being restricted by plant metabolic efficiency (cf. Hibberd et al., 2008; Yin and Struik, 2007). On the other hand, the *technical* room for raising the global output of existing crop varieties is sufficient to provide an affluent diet to twice the world population that is expected by mid-century - even if competing claims and unavoidable losses are included in the analysis (Koning et al., 2008). Innovations like C4 rice, algae, mariculture, biorefinement, and attractive meat substitutes might further increase this margin in the future.

However, the full realisation of the potential that technical scientists identify will be prevented by economic constraints (ibid.):

- Producers are profit maximisers. So diminishing returns make them stop short of achieving the maximum from the techniques they are familiar with. For instance, realising the above mentioned technical potential for crop production would require a sixfold increase in the global irrigated area (ibid.). Diminishing returns to irrigation investment will make the real increase a far cry from this (many experts would be happy with 50%).
- Pushing back diminishing returns requires considerable research investment to extend existing production functions. However, such investment is constrained by its profitability. In the 20th century, agricultural research gave high returns (Alston et al., 2000), but this was due to cheap fertiliser, and to the room, which is now being depleted, for breeding plants that could transform more fertiliser into harvested parts by improving plant architecture, crop duration and the timing of crop development. Whether research for realising the remaining potentials for raising food production will give comparable returns is highly uncertain.
- The progressive depletion of the world's reserves of fossil fuels and phosphate rock (Cordell, 2008; Smil, 2000) will raise the costs of many farm inputs, especially fertilisers. Compensating for this by improving efficiency is difficult. The energy efficiency of modern ammonia plants is approaching the chemical maximum (Jenssen and Kongshaug, 2003; Smil, 2001). An improvement of fertiliser-use efficiencies will in its turn be complicated by the need to raise production on less suitable soils.
- In many developing countries, producers face less favourable input-output price ratios than their counterparts in developed countries, as well as higher risks and transaction costs. Therefore they may opt rationally for simple technologies that give a lower output per hectare, but which require fewer inputs for maintenance. (See the schematic representation in Figure 2.3, which shows that with less favourable price ratios, profit maximisation may require techniques that allow a lower maximum output.) As these countries contain a large part of the world's unused potential for farm production (Penning de Vries et al., 1995), the consequences for global food supply will be far-reaching.

Figure 2.3 **Schematic representation of the selection of farm techniques in favoured and less-favoured areas.**



The straight lines are price lines with the ratio of input prices (**p_x**) and output prices prices (**p_q**) as slope. Profit (**π**) is maximised by selecting the point on production functions through which the price line with the highest intercept with the output axis can be drawn. For farmers in favoured areas (low ratios of input prices to output prices) this point is located on the production function of modern high input systems, but farmers in less-favoured areas will select traditional systems.

Hence, as always in human history, global food supply will reach an economic ceiling long before the technical potential that may be perceived from the vantage point of the world's technological frontier has been exhausted. Adequate policies can push the ceiling upward, but surpassing it requires new breakthroughs that may be hard to realise. Seen in this light, the technical potential for feeding two or three times the expected world population does not exclude a trend change in the coming decades. The long-term decline in food prices might cease or give way to a new long-term increase.

Influence of biofuels

These concerns are exacerbated by the recent biofuel boom. Liquid biofuels were important in the Interbellum period especially in the US, but had largely been replaced with fossil fuels at the eve of WWII. They re-emerged strongly in Brazil in the 1970s, but elsewhere only from the turn of the millennium. Today, over 90% of liquid biofuels is bioethanol, mainly produced in Brazil (from sugarcane) and the US (from corn). Biodiesel is mainly produced in the EU, from rapeseed, sunflower- and other oilseeds. Brazil, the EU and the US together accounted for over 90% of global biofuel production in 2006. The recent boom in first-generation agro-fuels has several causes. One is 'peak oil': environmentalists, major oil companies and academic energy specialists are warning that the increasing scarcity of fossil fuel makes it imperative to develop new energy sources. The oil price rise between 2004 and mid-2008 has given a further boost to biofuels - also because biofuels can use the existing infrastructure for oil or gas products (distribution and retailing systems, cars, combustion systems), which makes them more competitive than other alternative energy sources. Besides, the discussion on CO_2-caused global warming has created a favourable situation for the stimulation of alternative energy systems including biofuels. Furthermore, the dependence of fossil fuel-importing countries (especially the US and the EU) on producing countries that are seen as unreliable (Russia, the Middle East, Venezuela) generates pressures to lower this dependency. Finally, problems of agricultural surpluses and low farm incomes in many OECD countries have created a fertile ground for searching for new outlets for agricultural products.

There is widespread agreement that the rapid increase in the production of biofuels in Brazil, the US and the EU was one of the factors that contributed to the spike in food prices in the first half of 2008 (Banse et al., 2008a; Mitchell, 2008; Rosegrant, 2008). It has been claimed that biofuels have a stabilising influence on agricultural markets by introducing a floor and a ceiling effect (Schmidhuber, 2007). However, the levels at which these effects occur depend on energy prices. The latter are themselves highly unstable, which affects the validity of the argument. Various observers expect that biofuels will have an upward effect on international food prices in the years to come (OECD-FAO, 2008). Banse et al. (2008b) project that the proposed 10% mandatory biofuel use in EU gasoline (draft EU directive on promotion of the use of energy from renewable sources) and biofuel initiatives of other countries will change a 13% decrease in cereal prices between 2001 and 2020 into a 6% increase, and a 7% decrease in oilseed prices in a 19% increase. How the competition between foods and biobased non-foods will evolve in the longer term is highly unpredictable. Many people expect that biorefinement ('second-generation biofuels techniques') will moderate this competition because it will reduce the area requirements per unit of non-foods. However, these techniques will also reduce the cost price of non-foods, which will have the opposite effect (also cf. Meeusen and Van Tongeren, 2006; OECD, 2006). Moreover, new increases in energy prices will reinforce the competition between non-foods and food.

Governance needs

Hence, we are confronted with two interrelated threats to future food security: food price instability and potential new scarcity of food. The development of crop-based biofuels has strengthened these threats. The possibility for the global supply of food to keep up with the growth in demand may vitally depend on global institutions that (i) ensure timely investment in the world's capacity for producing biomass, (ii) stabilise agricultural prices to facilitate this investment and protect the poor against sudden rises in food prices, and (iii) balance the use of biomass for food and non-foods.

In the next sections, we review the evolution of institutions for regulating the markets for agricultural products, fossil fuels and biofuels. We discuss to what extent these institutions may help to achieve the above aims. We start with the regulation of agricultural markets.

2.3 Regulation of agricultural markets

Market intervention and attempts at multilateral regulation

Since the regime change from scarcity to (over)abundance in international agricultural markets in the 19th century, ever more countries have intervened to stabilise and support their domestic farm incomes. Most West European countries started doing so in the late 19th century. All other OECD countries followed in the 1930s (Koning, 2008; Tracy, 1989). After the 1950s, many Asian developing countries followed their example (Dawe, 2001; Francks et al., 1999; Kajisa and Akiyama, 2005; Timmer, 2002). These policies mostly enabled a rapid agricultural development that contributed to overall growth, reducing poverty and food insecurity (Dorward et al., 2004; Koning, 2007). Conversely, poor countries that failed to stabilise and/or support farm prices have seen their agriculture stagnate. Agricultural stagnation dragged the rest of the economy with it, leaving large parts of the population poor and vulnerable to fluctuations in food prices (Koning and Smaling, 2005).

Without supply management, however, national policies for supporting or stabilizing agricultural prices distorted world markets by causing import substitution and dumping. In the 1930s-40s, therefore, the League of Nations, the U.S. Department of Agriculture, the FAO, John Maynard Keynes and others advocated a multilateral regulation of international markets through price bands, buffer stocks, and in some cases production and export controls (Chimni, 1987; Henningson, 1981; Keynes, 1943). It led to the first attempts at international commodity agreements for major crops. In a similar vein, the General Agreement on Tariffs and Trade (1947) envisaged the regulation of agricultural markets through managed trade rather than free trade. It allowed countries to conclude commodity agreements to stabilise world markets (article XX) and to support their own agriculture provided that they controlled their domestic production and exports (articles XI and XVI).

Mercantilism and pseudo-liberalisation

In the decades that followed, however, the US and the EU thwarted this pursuit of a multilateral regulation. While blocking supportive control agreements for tropical export crops (Chimni, 1987; Maizels, 1992), they protected their own farmers without respecting the GATT conditions that bound such support to production and export controls. As a consequence, both blocs were dumping increasing volumes on the world market. In the 1980s, the mutual dumping of grain and grain substitutes caused a trade conflict between the two powers. This dominated the agricultural negotiations during the Uruguay Round of GATT negotiations. After six years of stalemate, bilateral negotiations between the US and the EU led to a compromise (Blair House Agreement), which was enshrined in the WTO Agreement on Agriculture. It prescribed countries to reduce their price supports for agricultural commodities. At the same time, however, it exempted certain forms of direct payments, also from the original GATT obligation to couple supports to supply management (Koning, 2008). Since then, both the US and the EU have been shifting from price support to direct payments to farmers, allowing them to continue exporting farm products for prices below their own costs of production (Ritchie et al., 2003). The extent of this 'dumping in disguise' was widened by the abandoning of remaining production controls: the set aside programme in the US in 1996 (Ray et al., 2003), and the phasing out of the milk quotas in the EU as is happening today.

Although mercantilist interests played a prominent role in this policy change, it was accompanied by a discourse on 'trade liberalisation'. This reflected a more general paradigm shift in economics and economic policies. The growth disturbances of the 1970s had discredited the 'neoclassical-Keynesian synthesis' that had dominated the economics discipline in the first postwar decades, and that had advocated active government intervention for achieving socio-economic aims like social security and full employment. It catalysed a 'micro-economic revolution' that reduced the role of government once again to the classical night watchman state. In agricultural economics, this revolution entailed the abandoning of an older institutionalist approach that had highlighted the rationale for government support (Gardner,1992). According to the new consensus, such support was unnecessary and could only hamper economic growth and hurt poor consumers. Studies based on computable general equilibrium models claimed that multilateral trade liberalisation would benefit developing countries (e.g. Anderson and Martin, 2005; Anderson et al., 2006). Trade liberalisation was also expected to reduce price instability as it would allow harvest failures and bumper harvests in different places to cancel each other out (e.g. Bale and Lutz, 1979). Besides, the idea was that private stock holding could take over the stabilising function of public stocks. Accordingly, the World Bank and the IMF pressured many developing countries to abandon public stock holdings. Also, it was thought that futures markets could reduce price risks for smallholders in developing countries. The World Bank experimented with devices to allow smallholders to participate in these markets as an alternative for international commodity agreements which it deemed economically unviable. Last but not least, it was thought that private investment could take over the role of public investment in agricultural research. Part of the WTO agenda was the strengthening of intellectual property rights to stimulate private research investment.

Mercantilist interests seized upon the new economic orthodoxy, adopting a liberal-economic discourse to justify the shift to direct payments. The result was an uneasy marriage. More principled free-market economists were disappointed with actual reforms in developed countries. Nevertheless, their theories allowed these reforms to be justified as an intermediate step towards real liberalisation, rather than to be denounced as a pseudo-liberal continuation of offensive protection.

Short-term- and long-term effects

In the short term, the policy reforms have made agricultural markets more prone to price fluctuations. External influences that cause changes in supply and demand do not always cancel each other out. Environmental disturbances like El Niño may have a global effect, and the same holds for global economic booms or recessions. Moreover, liberalisation strengthens the effect of myopic expectations on prices. The major part of farm production is traded in domestic markets, where decreased price stabilisation has increased the scope for cobweb cycling. Some agricultural economists (like Boussard's group in France; Boussard et al., 2006) predicted this effect, but their warnings went unheeded by policy makers and their mainstream colleagues. The running down of public stocks in the US and the EU as part of their policy reforms also reinforced price instability. Private stock holding does not compensate for this because it is less anti-cyclical. As has now become clear, rising prices may induce entrepreneurs to retain stocks in the expectation of further price increases, so that price rises are reinforced rather than moderated. Something similar holds for futures markets, which can only reduce price risks for producers if futures prices are not too far removed from spot market prices (Banse et al., 2008a). The speculation in these markets has become such that the two prices diverge and the underlying price instability is increased. Besides, experiments with arrangements to allow smallholder farmers in developing countries to participate in these markets have met with poor results.

The opening of OECD markets may benefit larger farmers in agricultural exporting and middle-income countries like Australia or Brazil. However, it is questionable whether agricultural trade liberalisation would stimulate the development in poor countries. Many poor countries themselves need protection to get their agriculture moving (Koning, 2002; Koning and Smaling, 2005). Besides, reduction in price support in OECD countries erodes the value of arrangements that give many poor countries preferential access to OECD markets (Panagariya, 2005; Yu, 2007).

In the longer term, 'liberal' reform might precipitate a reversal in the secular trend in food prices. Increased price instability discourages timely investment in research, human capital and infrastructure. Direct payments stimulate the increase in agricultural production capacities less than price supports do. Additionally, they involve higher budget costs, strengthening pressures for reducing the level of farm income support. The cuts on public investment in agricultural research have similar effects. From 1976-81 to 1991-2000, the growth of this investment fell from 4.5% to 1.6% yearly (Pardey and Beintema, 2001; Pardey et al., 2006). This has not been compensated by private investment, whose growth rate also declined after the 1980s.[1] Moreover, private research investment is one-sidedly focused on objectives like pesticide tolerance. Objectives like drought tolerance - important for raising production in many less-favoured areas - are being neglected (Pingali, 2007).

The reduction in price stabilisation also increases the risk that price fluctuations will interact with a change in the long-term trend in a way that may cause unnecessarily high rises in food prices. For example, it is widely assumed that the low prices and cuts on research expenditures in the 1980s-90s have reduced investments in agriculture and that this has contributed to the recent price rise. Suppose that when the global recession is over, prices will rise again, like many observers expect. And suppose that this will prompt a rapid exploitation of the last margins for cheap increases in the global farm output that still exist in countries

[1] Oral communication Nienke Beintema.

such as Brazil and Russia. After some years, this may induce a new price fall, which may once more squeeze longer-term investment in the world's carrying capacity for food production. If this were to coincide with a change in the long-term trend, the result might well be a period with stronger price rises than have taken place in the last few years. The undershooting of the outgoing trend investment would then involve a larger undershooting of the new trend, which would prompt a correspondingly large increase in prices above this trend (see right-hand part of Figure 2.2). In this admittedly worst case scenario, a tripling or quadrupling of grain prices cannot be excluded. Such a price rise would hardly affect food security in rich countries. However, it would wreak havoc in poor countries, and the effects would certainly be felt in other regions too.

2.4 Regulation of fossil fuel markets

By the growing use of biomass for energy production, agro-food markets are increasingly related to energy markets. Energy prices and their fluctuation are thus more directly affecting food prices. Hence, the governance of agro-food markets can no longer be isolated from that of energy markets. What institutions for regulating energy markets have evolved, and how successful are they in stabilising energy prices?

Compared to agricultural commodities, energy commodities (i.e. oil and gas mainly) are much more subject to exchange on a world market, especially because production is limited to only a few countries. Oil was the first fossil energy source that was widely traded. Fluctuations in oil prices are politically sensitive in current energy-dependent societies, not unlike fluctuations in food prices. Some oil market speculation is directly related to the political stability of certain states. Concerns about this stability have from time to time driven up the price of oil. The oil market is exceptional in being so sensitive to the politics of volatile regions. Even the supply of natural gas is in general more secure, as it is not traded across oceans by tankers as extensively. Regionally, though, the production and piped transport of gas can also be tied up with political instability (Correljé and Van der Linde, 2006). Compared to agro-food production, however, the production and prices of fossil energy are only incidentally affected by environmental disturbances (like in the case of hurricane Katrina).

As energy has increasingly become a crucial commodity for modern societies, most countries have installed national policies for securing energy supply and controlling prices, and many energy production and distribution companies have been publicly owned and managed. In resource-rich countries, domestic energy prices are kept artificially low for political and economic reasons, while export prices are set at a different level through taxes (dual pricing), amongst other things. Traditionally, energy-importing states have installed stocks to balance shortfalls in oil delivery, but less so for gas. Like public food stocks (see previous section), these stocks have diminished in recent years, making oil price fluctuations more immediate and stronger.

The 'supermajors' (first the Seven Sisters, now the six largest multinational oil companies) have had an impact on international energy prices for quite some time. But with the establishment of the OPEC[1] in 1960 and especially since the OPEC's political activism in the 1970s, the power of multinational oil companies to influence prices has decreased significantly. The large multinational companies currently control just 5% of world oil and gas reserves. OPEC states and OPEC state-owned companies control 50% of oil trade and produce about 40% of world oil (though only 16% of world natural gas).[2] It is likely that the multinational companies will continue to lose power to state-owned and state-controlled companies (increasingly of non-OECD countries). In contrast to agro-food trade, rather than import barriers, export barriers (restrictions and taxes, sometimes differentiated to different markets) and dual (domestic and export) prices of energy exporting countries are debated in energy trade liberalisation.

For a long time, fluctuations in international oil prices remained limited (cf. Figure 2.4). However, between the early 1970s and the mid 1980s, and again since the late 1990s, oil prices have fluctuated strongly. In the 1970s, OPEC policies and political instability of oil-exporting countries (e.g. Iran) were mainly responsible for limiting production and raising prices. However, recent price rises are attributed to several drivers: lack of stocks/reserves, political instability in oil-producing regions, lack of buffer production capacity due to poor investments, demand increases in emerging economies, and 'peak oil' (Wirl, 2008). These factors are thought to explain why price rises are not always and immediately followed by offsetting increases in the supply (Correljé and Van der Linde, 2006). However, energy prices also react strongly to global economic developments, which may thereby exacerbate price spikes and price falls.

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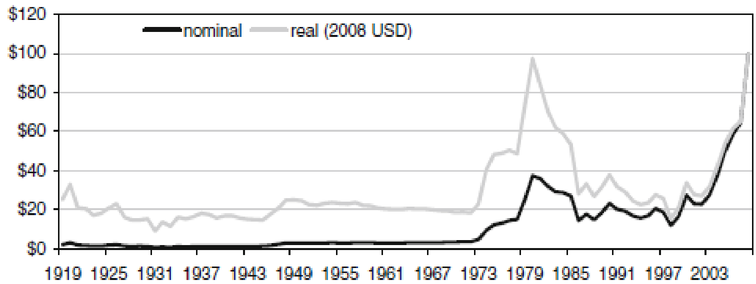
[1] The OPEC is still the most powerful multilateral institution (basically a public cartel) that aims to control market prices of oil by regulating production, basically for the benefit of its 13 member states (Algeria, Angola, Ecuador, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela).

[2] In late 2008, 15 major gas-producing and -exporting countries cooperating in the Gas Exporting Countries Forum, with headquarters located in Doha, Qatar, adopted a chapter to secure high gas prices. This is believed to have become an OPEC-like natural gas cartel.

Figure 2.4 **Average annual price of crude oil, 1919-2008**



Data source: www.eia.doe.gov.

World energy trade is not subject to a public multilateral regulation comparable to the WTO Agreement on Agriculture. The WTO has no energy chapter and no energy rules, and for a long time, energy was considered as a special commodity that did not fall under a WTO regime. Since the 1970s, oil and gas-importing countries have been demanding WTO regulation (focused on further liberalisation of energy markets), in order to make their access to energy less vulnerable to political developments. While many no longer consider energy ill-suited for WTO regulation, attempts to bring it under WTO ruling have been little successful so far. The first reason is that about 50% of the energy products that are traded globally comes from non-WTO members. Secondly, in WTO accession processes, future members often aim to prevent - or demand to be excluded from - energy service sector liberalisation, unbundling of energy monopolies, elimination of export taxes, and termination of dual prices. Thirdly, the world market, in the sense of a coordinating institution, has partly been replaced by bilateral or regional contracts by countries that thus try to secure their energy supply and stabilise their energy prices (e.g. gas contracts in Europe) (Selivanova, 2007).

Following the instability in oil prices over the last decades, we see several calls for an international UN organisation to bring order into the world oil (and to a lesser extent gas) market (cf. Glenn and Gordon, 2002; Kirton, 2003). Such a UN organisation should organise long-term contracts that provide security of supply related to security of demand. These calls move beyond the old plea for liberalisation from oil-importing countries and unilateral attempts at influencing oil prices by exporting countries. They are underpinned by environmental arguments (related to international climate policy) and by arguments linked to energy source diversification (the need to shift to renewables). Nevertheless, the contours of an international energy have yet to be seen.

2.5 Regulatory void in biofuel markets

Crop-based biofuels (agro-fuels) link agricultural markets and energy markets. Through them, movements in energy prices can influence food prices. Policies that stimulate or discourage agro-fuels have effects in both markets. In this section, we discuss the evolution of agro-fuel markets and consider how they are regulated.

Liquid biofuels have re-emerged from the turn of the millennium. (Only in Brazil, bioethanol was already widely produced in the 1970s.) During the first years of the new millennium, biofuels have been produced primarily for domestic markets, with hardly any cross-border trade. Governments in many countries have been stimulating these national markets in numerous ways. These include large R&D programmes; mandatory targets for biofuel use in gasoline and diesel; the subsidisation through tax reductions and credit facilities of farmers, biofuel producers, and various demand-side actors; experiments with transport technologies and programmes; and so on and so forth (Doornbosch and Steenblik, 2007; Mol, 2007). The prices of biofuels were strongly influenced by these policies. At the same time, protective measures against foreign competition prevented serious international trade in biofuels for several years. Because biofuel markets resembled fossil energy markets to some extent, and because one of the reasons for biofuel development was energy security, an interest of governments in price setting, protection and market development was to be expected. Yet there are two major differences with oil. Firstly, while oil is produced in a limited number of countries/regions, biofuels - or feedstock for biofuels - can be produced in many more countries. Secondly, for current biofuel feedstock production, fertile land (with inputs and water) is a prerequisite, which leads to competition with food.

Recently, international trade in (feedstock for) biofuels has been increasing. Besides energy companies and state agencies, farmer cooperatives, agribusiness and car companies have become involved in this trade. Estimates are that around 10% of the global biofuel production was traded cross-border in 2006. In addition, palm oil, soy and other feedstock for especially the production of biodiesel is traded internationally.[1] While we cannot yet speak of a globalised biofuel economy, and protectionism continues to exist, it is clear in which direction the development goes. The mandatory targets of liquid biofuel use in OECD

[1] This enabled Rotterdam to become a European hub in biofuel processing, although there is no abundance of cropland in the neighbourhood.

countries are driving increasing international trade, as many countries cannot meet their domestic demand. Increasingly, developing countries are moving into energy crop production. But their lack of hard and soft infrastructures might limit them to exporting feedstock, so that they would not fully benefit from their comparative advantage in biomass production by becoming exporters of (higher valued) biofuels (Mol, 2007). Foreign direct investment could prevent this. Indeed, US, Brazilian and European businesses see major commercial opportunities in developing countries. They are seizing these opportunities by supplying advanced equipment, setting up production and processing facilities, and investing in energy plantations in biomass-rich regions such as sub-Saharan Africa and Southeast Asia. However, the positive or negative consequences for local economies are not yet clear.

The emergence of a global market for biofuels has induced attempts at global collaboration on standards and specifications related to biofuel quality. In addition, it has led to a demand for ending protection and for multilateral liberalisation. There are some developments in this direction, and one can expect the WTO to try to become the leading framework for global biofuel regulation, in close relation to its agricultural chapter (Howse et al., 2006; Motaal, 2008). According to some, the biofuels issue could even help to overcome the existing deadlock in the agricultural trade negotiations in the WTO. It could help to legitimise the existence of the WTO, which is going through a difficult time now that bilateral trade agreements are partly replacing WTO agreements. However, how biofuels will fit into the existing WTO trade regime is not at all clear. Are they going to be defined as agricultural, industrial, or energy goods? This has consequences for the subsidies allowed and the kind of import tariffs they can be subject to (Motaal, 2008). Governments of biofuel-producing countries are increasingly convinced that import barriers need to be broken down, but they seem less willing to lift subsidies to their domestic primary producers, processors, and users. And what would be the consequences of a trade regime for domestic regulations and standards conforming to those of the WTO (e.g. mandatory use of biofuels, fuel content requirements, environmental conditionalities) (Dufey, 2006; Loppacher, 2005). Up till now these questions have not been clarified.

At the moment, the EU is arguably the most active regional government institution that develops biofuel policies which, though primarily meant for its internal market and member states, have significant consequences for international markets. The emphasis in EU biofuel policies (e.g. the 2008 draft renewable energy directive) is very much on stimulating biofuels, a little on the environmental side effects of biofuels, but not at all on the relation between biofuels and food prices.

Meanwhile, globally traded biofuels are also becoming subject to private forms of governance. Standard-setting agencies such as the International Standard Organisation are focusing on biofuels. Multinationals are developing corporate policies and coordinating international commodity chains and networks. We are also witnessing a blossoming of round tables, private labelling initiatives, and international networks and arrangements in which a variety of economic and civil society actors are working together, often assisted by governments, to facilitate trade and investment (Verdonk et al., 2007; Van den Hombergh, 2008; Mol, 2009). These emerging private governance arrangements to some extent address environmental side effects of large-scale biofuel production. Further coordination of the mushrooming private, public-private and public (inter)national initiatives (of individual companies, NGOs, multi-sector coalitions, nation-states etc.) could certainly help to mitigate such side effects and even to tackle some of the social issues in biofuel production. However, how these initiatives could address the influence of biofuels on international food prices remains entirely unclear.

In conclusion, a global market for biofuels is emerging, and it is strongly linked to both energy and agro-food markets. This biofuels market is still subject to significant national stimulation and regulation through mandatory market creation, subsidies, import tariffs, and the like. But the tendency is towards cautious liberalisation - perhaps in a WTO framework. Neither the national policies nor this incipient liberalisation are addressing the international competition between biofuels and food staples and its consequences for global food security.

2.6 Conclusion: institutional requirements for balancing agro-food and energy markets

What conclusions can be drawn from this review of the regulation of agro-food, energy and biofuel markets with a view to food security? Global food security is best served by stable agricultural prices. These prices should neither be too high to allow sufficient access to food for the world's poor in the short term, nor be too low to allow timely investment in the world's carrying capacity for biomass production in the longer term. Because agro-food and energy systems are becoming increasingly inter-related, stabilising agro-food prices within adequate price bands cannot be done without stabilising energy prices. Our analysis suggests that current global institutions are ill-designed for balancing agro-food and energy markets, and thus for securing food security.

Keeping the world market prices of major crops within desirable price bands requires arrangements that adjust the production of biobased non-foods to the situation of food markets. Private standards and certification schemes for biobased non-foods are not up to this task. No matter how important such arrangements may be for improving the environmental sustainability and the social impacts of biobased non-foods in the areas where they are produced, they are little suited for regulating the competition between fuel and food at the global level.

The WTO framework is likewise little suited for this purpose, at least as long as the WTO agenda is guided by the objective of trade liberalisation. As we have argued above, trade liberalisation does not redress important causes of price instability in agricultural markets. Neither will market deregulation help to keep the average prices of major farm staples at desirable levels. To keep the world market prices of major food staples within desirable price bands, rather than mere trade liberalisation, one would need a multilateral system based on *managed trade*. In it, public buffer stocks could be used for stabilising world market prices (also cf. Von Braun and Torero, 2008). Tax or other restrictions could be imposed on biobased non-foods - especially those derived from crops - when the world market prices of major food staples exceed a ceiling. Maximum export quotas and minimum import quotas could be imposed on high- and middle-income countries to defend a price floor. These quotas could be made saleable between countries to allow adjustment to shifts in comparative advantage.

Because of the increasing competition between foods and biobased non-foods, such arrangements cannot well be introduced on a commodity-by-commodity basis, as with the older international commodity agreements. The same consideration also pleads against the idea to leave the regulation of biofuel markets to a sectoral UN International Energy Organization or a UN World Environmental/Sustainability Organization. Rather what is needed, in our view, is a coherent system for coordinated supply management in several markets. This was the objective of UNCTAD's Integrated Program for Commodities in the 1970s, and of the Commodity Control Organization that Keynes proposed in his 1943 blueprint for the post-war economic order (Keynes, 1943; Maizels, 1992). The marriage of mercantilism and economic orthodoxy that inspired the liberalising agenda for agricultural trade in the 1980s has got these ideas into the bad books of the international political community. Nevertheless, the coming competition between food, feed and fuel, and the warning that has been given by the 2008 price spike, may be reasons for reconsidering the issue. The current ambivalence towards under-regulated markets that has followed the financial crisis also creates a more favourable climate for such a reflection.

2.7 Acknowledgements

We thank Gertjan Becx, Martin van Ittersum, Roel Jongeneel and two anonymous referees for valuable comments and support. The responsibility for the content of this paper remains that of the authors.

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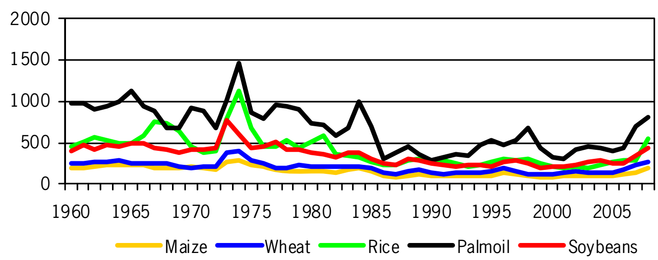
3 The rise and fall of world food prices[1]

Martin Banse, Peter Nowicki and Hans van Meijl

3.1 World agricultural prices in a historical perspective

World agricultural prices are very volatile, which is due to traditional characteristics of agricultural markets such as inelastic (short run) supply and demand curves (see Meijl et al., 2003).[2] The volatility is also high because the world market is a relatively small residual market in a world distorted by agricultural policies.[3] The combination of high technological change and inelastic demand have caused real world agricultural prices to decline in the long run (a hundred-year trend). Figure 3.1 demonstrates this long-term trend of declining real agricultural world prices and it seems that this trend has weakened since the mid-80s.

Figuur 3.1 **Development of World Agricultural Prices, 1960-2008, USD/tonne, in constant USD (1990)**



Source: World Bank data base (2009).

[1] This document is financed by the Dutch Ministry of Agriculture, Nature and Food Quality. It is based on internationally published literature, own research and consultations with experts in the field of world agriculture market analysis. We consulted the following experts: Gerrit Meester (LNV), Patt Westhoff (FAPRI), Pierre Bascou (EC), Catherine Benjamin (INRA), Loek Boonekamp (OECD), Ron Trostle (ERS/USDA), Pavel Vavra (OECD), Willie Meyers (FAPRI) and Pierre Charlebois (Agriculture and Agri-Food Canada).

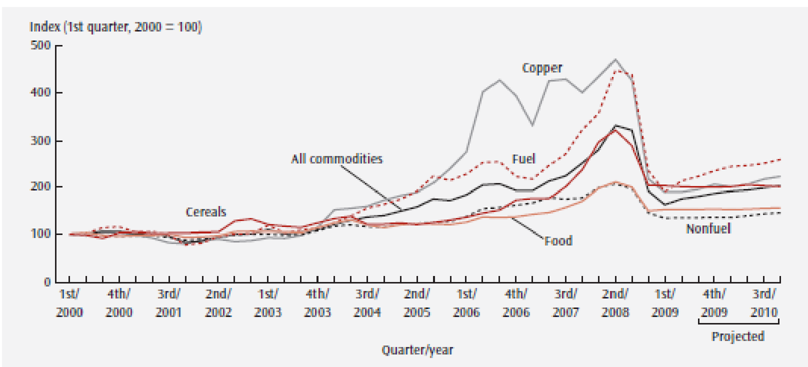
[2] 'World food prices are instable and will remain unstable in the future. Forecast errors are large in predictions of world prices. There are always unexpected events in important drivers such as yields which are dependent on weather, plagues and diseases'. See, Meijl, H. van et al. (2003: p 11).

[3] Trade share (2006) in global production: rice (7%), cheese (7%), coarse grains (11%) and wheat (20%), FAO Statistics.

The price increase since 2005 was strong, but even with the increase that we have observed in the 2005-2008 period, real agricultural prices are still low compared to the peaks in prices of the mid-70s. Local prices are linked with these world prices. The transmission effect depends on the transparency of markets, market power and accessibility.

Figure 3.2 depicts the recent rise and fall of the price index for cereals and food commodities along with an index for the average of all commodities and indexes for fuel, non fuel and copper. Although the food commodity index has risen considerably until mid-2008, the index for all commodities has risen much more. Cereal prices grew much faster than food prices and grew in line with the index for all commodities. The rise in copper and fuel prices was even much higher (four times higher than in 2000). In this perspective, the recent rise in food commodity prices is moderate. Furthermore, Figure 3.2 shows that since mid-2008 the prices dropped even quicker than they rose to a level that is above the level in 2000.

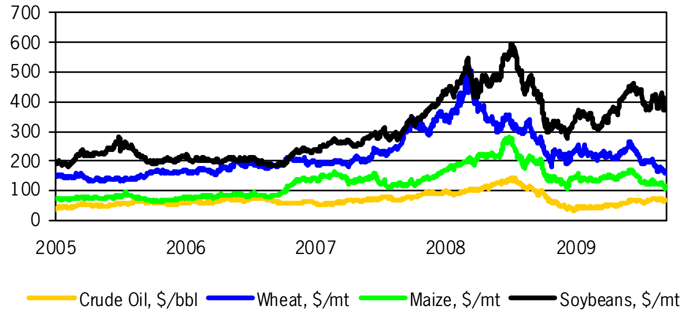
Figuur 3.2 **Price index of fuel, food and all commodities, 2000-2010, 1st Q 2000=100 a)**



a) Indexes are in US dollars
Source: IMF..

Figure 3.3 shows that spot prices for many (major) agricultural commodities have risen quickly from 2007 until mid-2008 (see Figure 3.1). Spot prices declined rapidly since early 2008 for wheat and since mid-2008 for soybean, corn and crude oil. Recently the price for crude oil and soybean went up a bit, while the prices for wheat and corn kept falling.

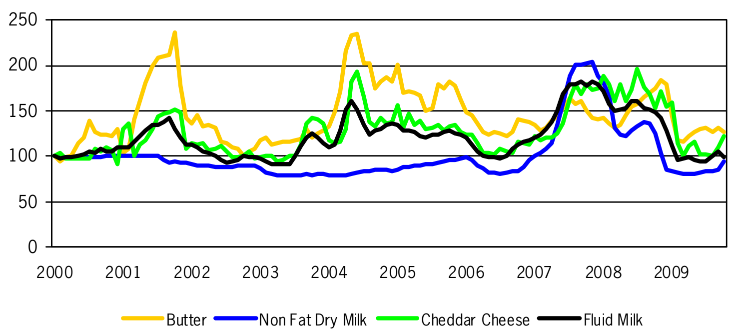
Figuur 3.3	Daily Price Notations for crude oil, wheat, corn and soybeans; spot prices, 2005-2009, at current USD



Source: World Bank data base (2009) from January 1, 2005 to September 10, 2009.

Figure 3.4 shows the development in world dairy prices. We see the peak in 2007-2008 for all dairy products and the very low recent prices. Since mid-2009 there have been some first signals that the world dairy price is recovering a bit. A comparison of Figure 3.2 and Figure 3.4 shows that unlike for most other products, the peak in 2008 has not been exceptionally high for Cheddar cheese and butter since 2000.

Figuur 3.4	Monthly price notations for milk, butter, non-fat dry milk and cheese; two-week average prices, 2001-2009, at current USD, Jan 2000 = 100



Source: USDA Agricultural Marketing Service (2009), downloaded from http://future.aae.wisc.edu/index.html, October 2, 2009.

Although real food prices are not extremely high in a historical perspective, and other commodity prices have risen more, an increase in the price of food - a basic necessity - causes hardships for many lower income consumers around the world. This makes food-price inflation socially and politically sensitive. This is why much of the world's attention is still focused on the increase in food prices in 2008 (Figure 3.3).

Price volatility

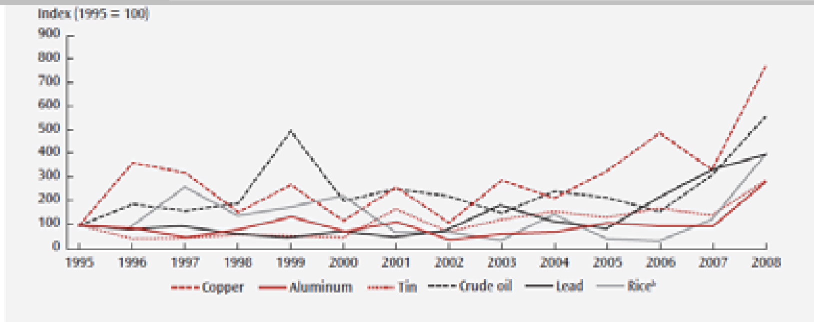
Table 3.1 and Figure 3.5 indicate that the volatility of agricultural as well as non-agricultural prices has increased over time. The standard deviation of selected agricultural commodities increased sharply in 2006, 2007 and 2008. There are indications that the volatility - measured in standard deviation - also declined with the slowdown of the absolute price level in 2009, see Table 3.1.

Table 3.1 Annual deviation of commodity prices (annual standard deviation), 2000-2009

	Wheat	Corn	Soybeans	Crude Oil (Brent)
2000	27.8	22.7	25.6	3.5
2001	14.2	9.2	27.5	3.4
2002	73.7	24.7	54.6	3.0
2003	30.7	12.2	72.6	2.5
2004	22.2	46.2	187.2	5.7
2005	29.7	14.5	58.4	6.2
2006	39.2	53.2	39.7	5.8
2007	151.7	34.6	134.7	11.9
2008	200.4	100.5	221.3	28.9
2009 a)	63.4	33.3	109.7	11.2

a) January 1 until September 10, 2009.
Source: World Bank Data base (2009), daily price notations.

Figuur 3.5 **Volatility of commodity prices, 1995-2008**



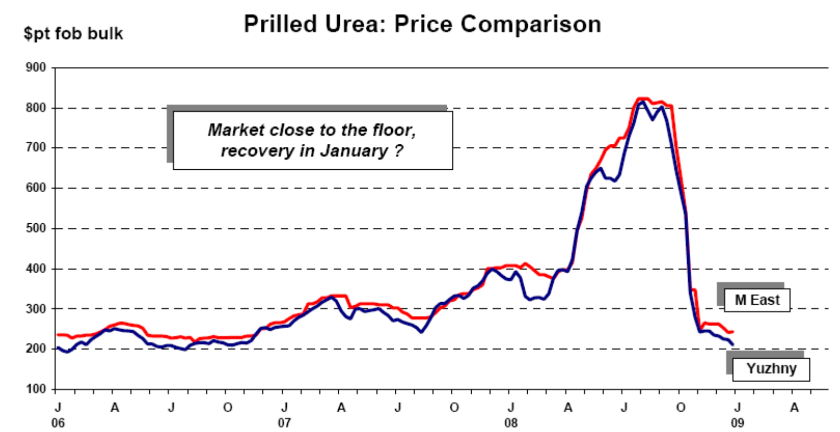
Source: Bloomberg and IMF staff calculations.
a. Volatility is calculated as the index of the annual coefficients of variation (standard deviation/mean) of daily commodity prices.
b. Due to the lack of data for rice, calculations use monthly commodity prices (for rice, the index is 1996 = 100).

Input prices

World prices developments for nitrogen and phosphate are shown in Figures 3.6 and 3.7, respectively. Like in the case of agricultural prices we see an enormous increase followed by an even sharper decline. Input prices peaked at the end of 2008 and therefore later than agricultural prices, which peaked early 2008 (wheat) or mid 2008 (corn, soybean). Therefore input prices follow output prices. The high agricultural prices in 2007-2008 induced higher production by an increase in area and increased intensification. Both effects lead to higher demand for inputs. As fertiliser industry production and distribution were unable to keep up with demand, prices increased sharply. When the input prices were so high agricultural producers substituted away from more expensive inputs to e.g. GMO crops and the use of less inputs.

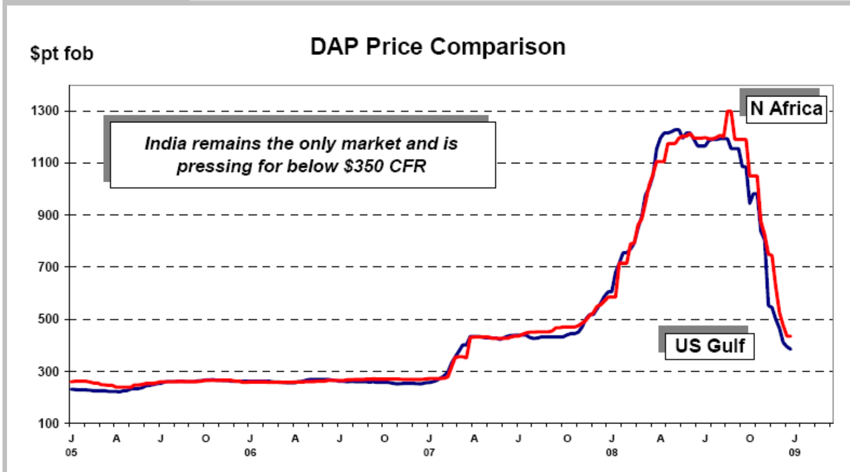
Input prices follow output prices with a time lag. The period of high food prices and still lower input prices induced high profits in agriculture. The period of lower food prices and still high input prices had a strong negative impact on farm profitability in that period.

Figuur 3.6	Price Development of Nitrogen (Urea), 2006-2009, USD per tonne



Remark: $pt = USD per tonne. Source: FertReports Archive (2009). www.fertiliserworks.com/fertreport/

Figuur 3.7	Price Development of Phosphate Fertiliser, 2006-2009



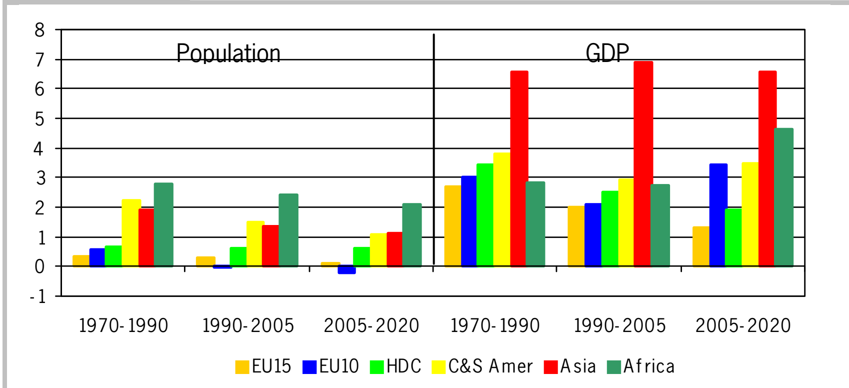
Remark: DAP is Diammonium phosphate, $pt = USD per tonne, CFR is standard of performance
Source: FertReports Archive (2009). www.fertiliserworks.com/fertreport/

3.2 Long-run effects

3.2.1 Long-run drivers of demand

Population and macro-economic growth are important drivers of demand for agricultural products. In past years, rapid population growth has accounted for the bulk of the increase in food demand for agricultural products, with a smaller effect from income changes and other factors (Nowicki et al., 2006). The world's population growth will fall to about 1% in the coming ten years, although total population will continue to mount for a few decades. Continued economic growth is expected over the coming period in almost all regions of the world and this driver of demand will become more important than population growth in the future (Figure 3.8).

Figuur 3.8 **World population and GDP growth (annual growth %)**



Source: USDA (2009a) and (2009b). HDC = High Income Developed Countries, C&S Amer = Central and South America

Expected population developments in period 2005-2020

The world's population growth will fall from 1.4% in the 1990-2003 period to about 1% in the coming ten years. This is mainly due to birth or fertility rates, which are declining and are expected to continue to do so. Almost all annual population growth will occur in low and middle income countries, whose population growth rates are much higher than those in high income countries. Europe's share in world population has declined sharply and is projected to continue declining during the 21st century as population growth in Europe is very low (0.3%

yearly for EU-15: old EU member states) or slightly negative (-0.2% for EU-10: new EU member states).

The uncertainty with regard to birth and death rates at world or regional level is not too large. However, migration flows between countries and regions are much more uncertain.

Global Income growth

Economic growth is expected over the medium term period in almost all regions of the world (see Figure 3.8) but is expected to be considerably higher for most of the transitional and developing countries than for the EU-15, the United States and Japan, in particular for Brazil, China, India and the new EU member states. Incomes in Europe are expected to increase slightly over the coming years. The annual income growth in Europe is expected to be about 1.3% for EU-15 and 3.4% for EU-10. World and EU economic growth in the future stays uncertain and depends on the amount of investments in education and research, on technological opportunities, on the degree of (labour) participation in the political, societal and market arenas, and on the liberalisation of world commodity and factor markets.

The expected robust growth of income per capita leads to more 'luxury' consumption in developed countries. This implies more convenience food, processed products (ready to eat) and food safety, environmental and health concerns. In developed countries the total amount of food consumed will only grow in a limited manner. However, in developing countries a higher income induces more consumption and a shift to more value-added products. Important is the switch from cereals to meat consumption, as an increased demand for meat induces a relatively higher demand for grain and protein feed. To produce 1 kg of chicken, pork and beef, respectively 2.5 kg, 4 kg and 7 kg of feed are required (Ephraim Leibtag, 2008).[1] Urbanisation and the migration of people from rural to urban regions is also an important driver of demand which leads for example to a higher meat consumption.

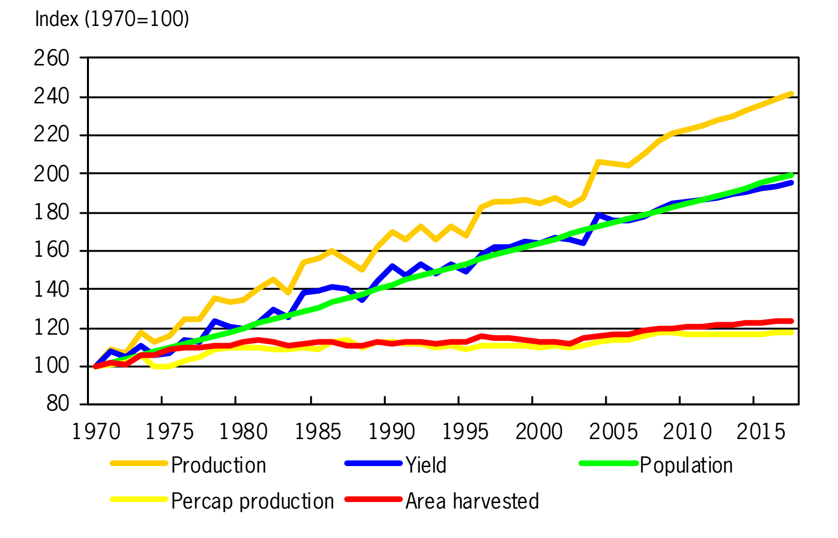
Long-term drivers of supply

With regard to crop production, yield and area developments are important drivers of supply. Figure 3.9 shows that production growth these past decades was almost totally determined by yield increase while the total area harvested

[1] The numbers describe upper-bound estimates of conversion rates: 7 kg of corn to produce 1 kg of beef, 6.5 kg of corn to produce 1 kg of pork, and 2.6 kg of corn to produce 1 kg of chicken. Modern technology, however, requires much less feed especially in pork production; here average feed conversion rates are between 3.2-2.6 kg of feed per kg of meat.

was more or less constant. The growth in yields declined from 2% per year in the 1970-1990 period to 1.1% in the 1990-2008 period. USDA expects the growth to decline to 0.8% per year for the period 2009-2017 (USDA 2009c, 2009d). At the global scale, crop production area increased in the 1970-2007 period by 0.15% per year, and USDA expects the area to grow by 0.4% per year in the period 2007-2017. We have to remark that the yield growth in absolute figures (tonne per acre) is more or less constant over time.

Figuur 3.9 **Development and projection of world grain and oilseed production, 1970-2017**



Source: USDA 2009c, 2009d.

The growth rates of yields for major cereals in developing countries are slowing. It should be mentioned again that the decline in annual growth rates is not necessarily related to a decline in absolute yield growth per annum. An important explanation for the decreasing yield growth rates might be the declining public agricultural research and development spending over time in both developing and developed countries (Pardey et al., 2006). Although private sector research has grown, private sector R&D is mostly cost reducing/short-run oriented instead of public R&D, which is often more yield enhancing/long-term oriented.

The direct link between R&D spending and yield growth had been intensively discussed amongst agricultural scientists and is not fully clear. The general outcome of this discussion is that an additional growth in yields requires not only basic R&D and capital stock, but also additional spending in investment in human capital stock (education), extension services, chain efficiency and improvements in market institutions (governance).

3.3 What explains the recent rise and fall in agricultural prices?

The sharp increase in world prices could be explained by a combination of record low global inventory levels, weather induced supply side shocks, surging outside investor influence, record oil prices and structural changes in demand for grains and oilseeds due to biofuels (Banse et al., 2008). In this section we study the causes of the price increase as well as the causes of the sharp decline in world prices since mid-2008.

Effects on the supply side
A poor harvest in Australia, Ukraine and rest of Europe for wheat and barley was one of the causes of the increase in prices. According to FAO statistics, these three regions contributed on average 51% of total world barley production and 27% of total world wheat production for the period 2005-2006. Certainly one of the main reasons of the decrease in prices has been the bumper harvest in 2008/2009. Favourable weather conditions and a larger than expected supply response last year were two key causes of the increase in production. Higher prices induced higher production and this leads eventually to lower prices.

Higher energy prices lead to higher food prices as costs (e.g. fertiliser, processing, and transport) increase. Higher transport costs induce higher price effects as distances increase. The sharp decrease in oil prices since mid 2008 (see, Figure 3.2) led to lower prices as production and transport costs declined;

Tight credit due to the recession does not seem not to be an important factor in the farming sector as the period with high prices increased the equity-debt ratio for farmers.

CAP policies such as a mandatory set-aside regulation or production quota restrained supply. Furthermore, there was a change from price to income support and compensatory payments became decoupled, set aside was introduced and export subsidies were diminished. Some of these measures limited supply within the EU; However, the general aim of the last CAP reforms was an enforcement of farmers' ability to react to market signals instead of following policy signals given by market price support. Measures aimed to restrict supply, e.g. production quota or set-aside requirements, are instruments designed for a world with declining prices, but which may act to reinforce prices in case of food shortages.

Low prices in the last decades did not provide an incentive to invest in productivity enhancing technologies. The increase in prices was too short to turn this trend around.

Table 3.2 shows a strong increase in the 2008/09 production of grain, especially for wheat and barley. While an increase in area sown for wheat and an increase in yields contributed to the bumper harvest in wheat, the barley and corn area declined (at the expense of wheat). For the next year world grain production is expected to decline mainly due to slightly lower yields compared to the 2008/09 level.

Table 3.2 World crop production - production, area and yields: 2007/08-2009/10

	Production (%)		Area (%)		Yields (%)	
	2008/09 vs 2007/08	**2009/10 vs 2008/09**	**2008/09 vs 2007/08**	**2009/10 vs 2008/09**	**2008/09 vs 2007/08**	**2009/10 vs 2008/09**
Grain	5.0	-1.9	0.3	0.1	4.7	-2.0
Wheat	11.7	-3.4	3.1	0.3	8.6	-3.7
Corn	-0.3	0.8	-2.2	0.6	1.9	0.2
Barley	15.7	-7.3	-3.8	1.3	19.5	-8.6
Rice	2.7	-2.6	1.1	-2.0	1.6	-0.6
Oilseeds	0.7	7.2	4.1	1.8	-3.5	5.3
Soybeans	-4.8	15.0	6.1	3.5	-10.8	11.4
Rapeseed	20.3	-2.8	8.5	3.3	11.7	-6.0
Sunseed	20.7	-2.1	9.5	0.9	11.2	-3.0

Source: Toepfer International Market Review, 21 August 2009. 2008/09 = Estimate, 2009/10 = Forecast

The low increase in global oilseed production is mainly due to poor harvests and export policies of soybeans in South America in 2008. In 2010 oilseed production, however, is projected to be more than 5% higher than in 2009.

Effects on the demand side

The demand in Europe and Northern America is constant; in Asian countries the demand will increase in the long run due to income growth and diet changes. In the short run demand is weakened due to the economic crisis. This weakness is expected to continue for the next few years and will put a downward pressure on agricultural prices. However, primary agriculture is quite resilient to lower income relative to other sectors due to the inelastic demand for agricultural products (see, also section 4 for some quantitative estimates). The impact of lower economic growth on luxury and processed products is higher.

Additional demand for biofuels:

- 5% of global oilseed production is processed to biodiesel or is used directly for transportation;
- 4.5% of global cereal production is used for ethanol production;
- Therefore, this extra demand triggered the markets during the price increase and might keep current prices above the 2005-2007 level;
- However, biofuels are not new. Ethanol based on sugar cane exists in an economically profitable way in Brazil for a long time;
- Increasing food and feedstock prices make biofuels less profitable and food more profitable. The current drastic decrease in oil prices and the relatively lower decrease in agricultural prices makes biofuels even less economic viable. The additional demand is therefore coming only from the biofuel policies, such as the EU Renewable Energy Directive.

Development of Stocks

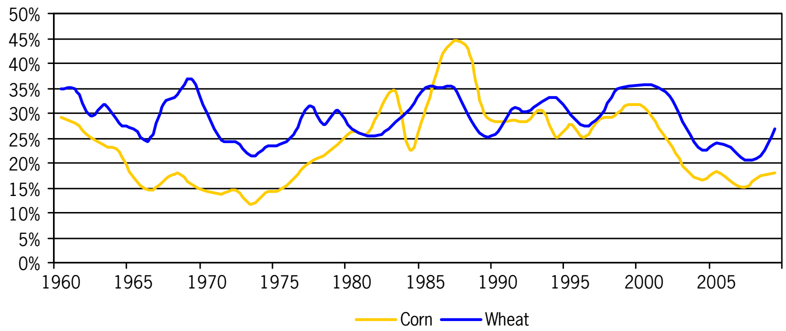
The trend of a declining stock to use ratio as described in Figure 3.10 has increased and stocks for wheat are currently running on empty. This implies that all the shocks mentioned above could not be mitigated by using stocks but lead immediately to price increases (see FAO, 2009:17). Furthermore, it enabled speculation; with stocks available there would have been less room for speculation.[1] Currently stocks are recovering but still low.

Whereas the causes of the 2008 price spike are documented - a production shortfall because of unfavourable growing conditions, coupled with price-insensitive demand for biofuels - the role of investments in agricultural derivative markets is also noted by the OECD, along with the absence of a sufficient buffer in the form of grain reserves. The OECD (2008: 5) notes that in the current situation 'Stocks [of wheat] are not expected to be fully replenished over the coming ten years, implying that tight markets may be a *permanent* factor in the period to 2017' and this 'provides the background for more price *volatility* in the

[1] A US Senate report, dated 24 June 2009, determined that index investments in the Chicago wheat futures market between 2005 and 2008, had caused unwarranted price changes in the order of a ten-fold increase in the average difference between the cash and futures price at contract expiration over the four-year period.

future.' Furthermore, a 'general point concerning price volatility relates to the 'thinness' of markets, or the small share of imports and exports relative to the size of global consumption or production.'

Figuur 3.10 **Development of stock to use ratio, 1960-2009**



Source: USDA (2009c).

Policy Responses to Rising Food Prices

The first response to the rapidly increasing world prices for food grains, feed grains, oilseeds, and vegetable oils, which were causing domestic food prices at the consumer level to rise in many countries, was to take protective policy measures designed to reduce the impact of rising world food commodity prices on their own consumers. In the fall of 2007, some exporting countries made policy changes designed to discourage exports so as to keep domestic production within the country. The objective has been to increase domestic food supplies and restrain increases in food prices. However, such measures typically force greater adjustments and higher prices onto global markets.

Effects of the Credit Crisis

Whereas the credit crisis has little impact on farm operations directly - although the investments in equipment and supplies may be restrained and the covering of operating costs between planting and sales may become more onerous - it is trade credit constraints beyond the farm-gate that are affecting the agri-food sector. The *OECD-FAO Agricultural Outlook 2009-2018* (OECD, 2009) highlights that financing of trade transactions not only between OECD and non-OECD countries has become more difficult, but even within the OECD, within the EU, and even within a country itself suffers from credit access difficulties. Trade credit has become a critical issue for firms that are focused on trade in bulk commodities and semi-processed products. Some firms that are financially sound have to reduce or even stop their activities. Note is made of African agri-food processing firms that no longer have access to imported supplies. With regard to repercussion on export, a Danish firm that has difficulties with trade in dairy and pork is given as an example of an increasingly current phenomenon, which is that the lack of trade finance availability in importing countries has an upstream impact through the reduction of markets for exporters. Some companies are experiencing that export credit insurance is no longer available, in particular for sales to particular trading partners depending on their country of operation. So demand down-stream from the farm-gate is decreasing because of the contraction of trade generally, and within the agro-sector in particular.

USD exchange rate developments
World prices are denominated in dollars and the dollar depreciated against most currencies. The increase in prices in other currencies is therefore much less. This will benefit the consumer for those countries whose currency is not pegged to the dollar, such as the European Union, but has a variable impact for both consumers and producers in countries which are obliged to float their currencies. Also, price movements in commodity markets have not been equal around the world. Producers in tropical countries - where cocoa, coffee, tea and cotton are the main export products - have benefited less from price increases in the past than producers in temperate countries, where the main export products are grain and oilseeds and who benefit from the food/energy linkage that has such a strong influence on these commodity prices.

Speculation
The impact of speculation on the current spike in agricultural prices is difficult to quantify. A formal assessment is hampered by data and methodological problems, including the difficulty of identifying speculative and hedging-related trades. A number of studies seem to suggest that speculation has not systematically contributed to higher commodity prices or increased price volatility, however, in recent reports find an impact of index trading and futures prices:

- For example, an IMF staff analysis (IMF, 2006) shows that speculative activity tends to respond to price movements (rather than the other way around), suggesting that the causality runs from prices to changes in speculative positions;
- Bange (2008) has argued that speculation may have reduced price volatility by increasing market liquidity, which allowed market participants to adjust their portfolios, thereby encouraging entry by new participants;

- The US Senate (2009), however, released a report on 24 June 2009 on *Excessive Speculation in the Wheat Market*, with the finding that index traders - having purchased huge numbers of wheat contracts on the Chicago exchange - increased futures prices relative to cash prices, and thereby created unwarranted costs and risks for wheat farmers, grain processors and consumers; the conclusion is a clear case of speculative money overwhelming a market.

3.4 First quantitative results of the analysis of key driving factors

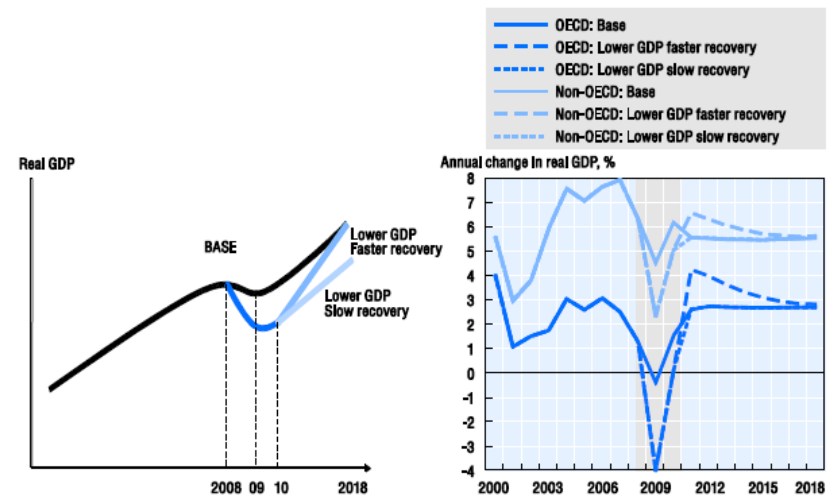
Demand for food is basically inelastic, and therefore the agri-food sector is more resilient than other sectors in the present crisis. But there are risks on the demand-side in the form of contraction of trade, in general, and through some change in diet, as some commodities - namely dairy and meat - have a higher elasticity of demand than others. Decline in real income will of course have repercussions in the quantity of consumption of even basic foods in the lower-income countries, and trade-related consumption will be dampened by the contraction of international trade.

Agricultural commodities have outlets beyond human consumption, however, so the demand-side is a composite of food, feed, fiber and food requirements. In this larger perspective, it is important to look at demand as being influenced both by GDP per capita and by energy prices, as energy prices and agricultural prices are more tightly connected (energy prices determine the economic viability of biofuels, but are also transmitted to agricultural inputs on one end of the agricultural commodity production cycle, and to freight charges on the other end).

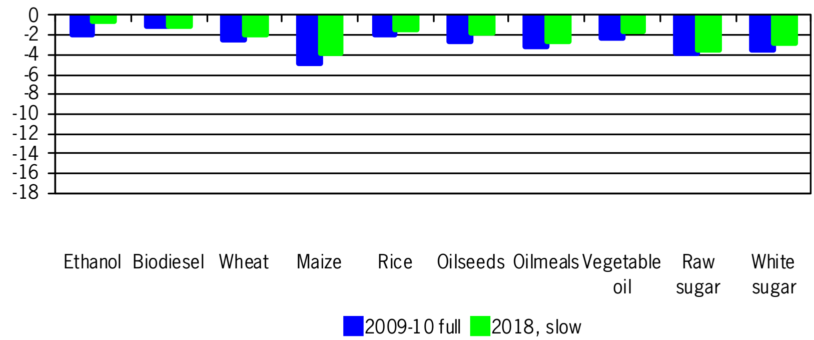
Due to the economic crises the projections for GDP growth declined for the EU-15 from 2% per year to about 1.3% per year for the 2005-2020 period (USDA 2009b). For the EU-10 the expected growth declined from 3.8% to 3.4%. For highly industrialized countries the projected GDP growth declined from 3% to 2% per year. For Asia and Africa the projected GDP growth rates are not much lower.

The OECD (2009) has performed a sensitivity analysis to take into account an even more severe inflection of GDP growth caused by the current economic recession in respect to the provisional baseline established by OECD: the alternative scenarios are (1) a rapid recovery period versus (2) a prolonged recovery, in the period 2009 to 2018 (Figure 3.11). The results show that prices of all commodities would drop below their baseline levels (Figure 3.12 and Figure 3.13). Crop products and biofuels show less elasticity of demand than dairy and meat products. The simulated price decline due to lower GDP growth is therefore much lower than for livestock products. In the case of biofuels, the response is even less pronounced than for crop products, because of the policy-set mandates. In terms of crop products, those which are more predominant as part of the diet of lower income countries witness the greatest impact of greater contraction of GDP than in the baseline. The exception in elasticity in higher income countries concerns sugar, which is more sensitive to income levels.

Figuur 3.11	Stylised depiction of economic downturn and two alternative recovery assumptions relative to baseline (left panel), and aggregate annual income growth assumptions for OECD and non-OECD regions across scenarios (right panel)

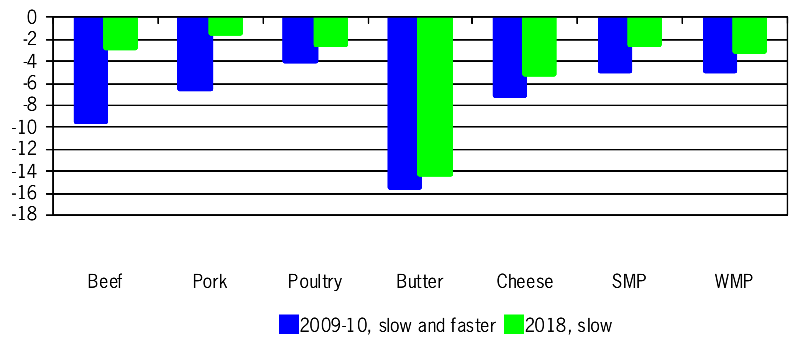


Figuur 3.12	Percentage change in biofuel and crop prices with lower income growth in alternative GDP scenarios compared to baseline levels



Source: OECD (2009) p. 36.

Figuur 3.13	Percentage change in meat and dairy prices with lower income growth in alternative GDP scenarios compared to baseline levels



Source: OECD (2009) p. 37.

A second sensitivity analysis was with regard to a lower oil price, a severe cut in the USD price per barrel. Here it turns out the crops are much more sensitive to the price of crude oil than livestock products. The price transmission that increases the cost of livestock production is much less than for crops. With regard to crops, price transmission affects fertiliser, chemicals and fuel prices, because of the high energy share in total production costs. For livestock, the co-production of dried distillers' grain (DDG) with biofuel production serves to counter-balance increases in the crop-based feed prices through substitution; and the part of energy in total production costs is in general lower.

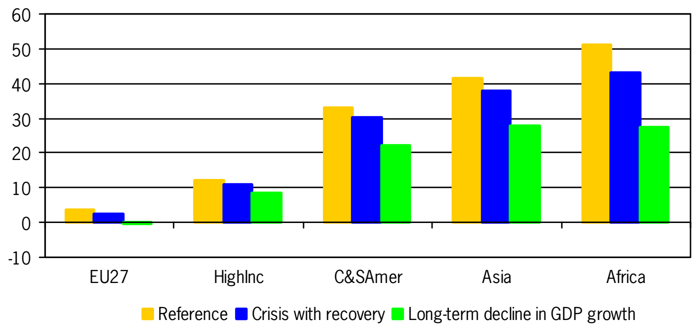
Effects of GDP growth rates around the world

The current economic crisis also reveals how fragile different regions of the world are with regard to the impact of GDP changes on agricultural production. In a sensitivity analysis we have carried out, the USDA data of 2008 are used to construct a Reference scenario for the evolution of agricultural and food production in the period 2007-2020, accompanied by two alternative scenarios that are (1) a brief but severe economic contraction followed by rapid recovery and (2) a prolonged period of deep economic recession (GDP growth rates stay low for whole period). To perform these analyses we used the modeling framework, especially the LEITAP model, of the Scenar 2020 update project (Nowicki et al., 2009 - forthcoming).

Figure 3.14 shows a somewhat synchronised response in a downward inflection of agricultural and food production growth rates in the case of rapid plunge and recovery of GDP, whereas there would be a certain leveling of these growth rates for most parts of the world in the case of a prolonged recession. What can be noted in the second case is that the magnitude of the decrease in production growth rates differs according to the level of income and the height of the GDP growth rate. The higher the growth rate in the reference scenario and the lower the income per capita, the higher the decline in agricultural and food production. A low level of income per capita implies that a larger share of income is spent on agricultural and food products, and reduction in income then has more negative effects on food consumption. As domestic production is still the main source of domestic consumption the decrease in production is relatively high in Central and South America, Asia and especially Africa. The general decrease in production growth rates for the Highly Income countries (including the EU) shows a simple step-wise reduction in production.

Figure 3.15 shows the impact of the GDP scenarios for livestock production, which apparently is the predominant influence on the agricultural and food production situation as a whole in response to different assumptions about the recovery from the current economic crisis. Growth rates are much higher than with regard to crop production (Figure 3.16), but the negative shocks from GDP changes are more severe, and the growth rates level out in the non-high income countries if there should be a prolonged period of economic recovery. Demand

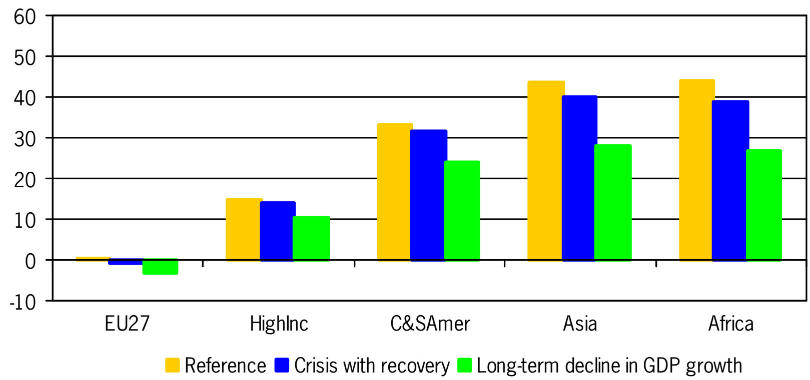
Figuur 3.14 **Development of agri-food production under alternative GDP scenarios, 2007-2020, in percent**



Source: LEITAP calculations. Rates of GDP growth in the Reference scenario derived from USDA (2008).

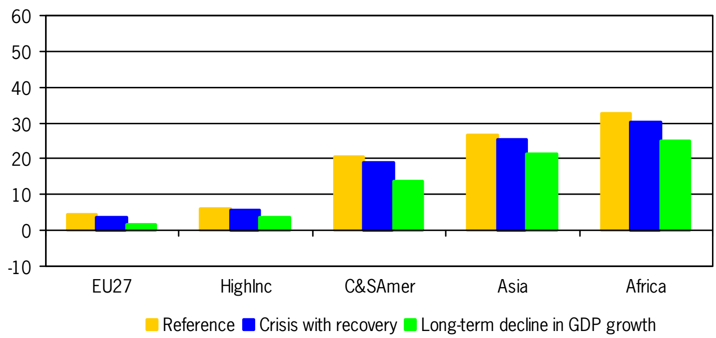
for meat is quite dependent on income, because of relatively high income elasticity of meat demand. Therefore, meat production in lower income countries and countries with high GDP growth rates is hit hardest by a severe recession. Within the group of less developed countries Central and South America are more resilient, Africa is hardest hit. The high-income countries (excluding the EU) do not fare too badly, but the EU livestock production contracts below current levels in the second scenario.

Figuur 3.15 **Development of livestock and meat production under alternative GDP scenarios, 2007-2020, in percent**



Source: LEITAP calculations. Rates of GDP growth in the Reference scenario derived from USDA (2008).

Figuur 3.16	Development of agricultural crop production under alternative GDP scenarios, 2007-2020, in percent

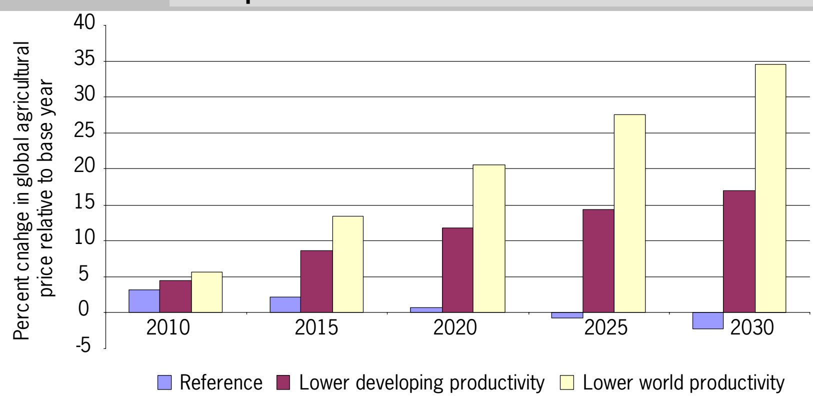


Source: LEITAP calculations. Rates of GDP growth in the Reference scenario derived from USDA (2008).

The impact of lower yields on world prices

The influence of productivity on agricultural prices offers another perspective. Figure 3.17 shows that all influences that decrease productivity are mirrored in the increase of prices. In the reference scenario real prices are expected to decline in 2030 conform (according to) the long-term trend (see Figure 3.1). Lower yields have a very high impact on agricultural prices and if yields fall short in the near future real prices can increase substantially. It is apparent that the impact would be greater if productivity decreases all over the world, as opposed to only the developing world.

Figuur 3.17	World agricultural prices are sensitive to productivity assumptions



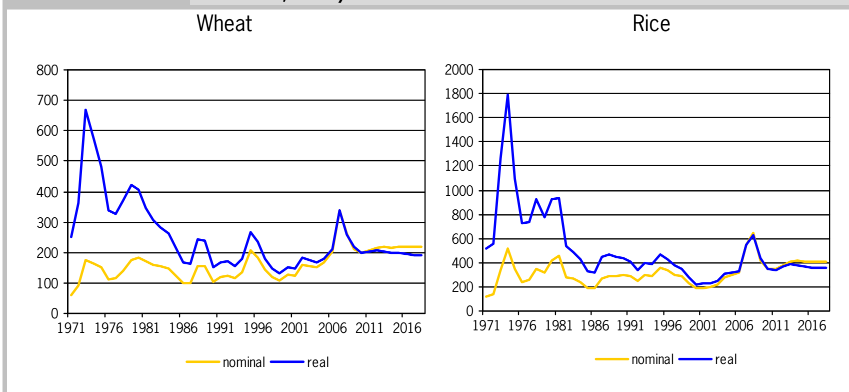
3.5 The future

Price developments in 2008 and 2009 showed that high prices are their own worst enemy. Increased profit margins enticed entrepreneurial investment, which resulted in increased production. Lower market prices inevitably follow. The 'invisible hand' of Adam Smith ensures that winners' gains and losers' losses will be temporary, as entrepreneurs correct market imbalances.

Higher prices induced more production as planted areas increased and available arable land was used more intensively. Therefore, the high price situation was not structural and as a result prices went down again. However, first stocks have to be built up again. This effect takes some time. In Brazil and Russia there are ample opportunities for production growth as additional land can be taken into production, whereas in many other countries intensification is the only means to a production increase. According to USDA analyses, Russia, Ukraine and Argentina could be among the world's top grain exporters.

Food prices, however, are likely to remain above their pre-2007 nominal levels (see Figure 3.18).[1] Average crop prices are projected to be 10%-20% higher in real terms relative to 1997-2006, while vegetable oil prices are expected to be more than 30% higher (OECD, 2009). According to OECD meat prices are not expected to surpass the 1997-2006 level. Dairy prices are expected to

Figuur 3.18 **Food commodity prices trends 1971-2007, with projections to 2018, USD/tonne**



Source: OECD 2008, Rising Food Prices: Causes and Consequences.

[1] World Bank: Crisis upon Crisis (July 2009).

be slightly higher in real terms, due to higher energy and vegetable oil prices, with a 12% increase for butter as most notable.

Both commodity and food prices are expected to rise once global growth picks up, because the demand pressures from rapidly industrialising emerging economies will continue to generate demand-side pressures. The evolution of cereal prices is positively influenced by policy-mandated biofuel demand; but a second reason is the increase in global requirements for animal feed. As the world population is expected to grow to 8.3 billion and the middle-class multiplies some seven-fold by 2030, a considerable surge in the demand for meat is also expected[1].

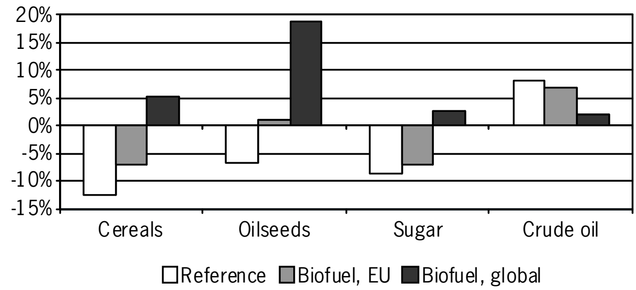
The volatility of commodity prices creates instability and uncertainty on global agricultural markets. It affects governments, producers, processors, traders, and local financial institutions. Moreover, commodity price instability undermines economic growth and skews the distribution of income. As a result nearly every government has tried to manage commodity price risks. Most early attempts to deal with commodity price volatility tried to stabilise prices with buffer funds, buffer stocks, international commodity agreements, or government intervention in commodity markets. Such schemes have failed to stabilize commodity prices. Buffer funds have either gone bankrupt or have proven ineffective. International commodity agreements have lapsed, as with those for coffee, cocoa, tin, and sugar. And government intervention has been costly, with unintended consequences. Today's discussion to limit price volatility on world agricultural markets with buffer stocks or even 'virtual' stocks should keep in mind that open and unconstrained trade is a much more effective and less costly instrument to reduce price volatility than creating buffer stocks (Abbott, 2009: 42).

With regard to the future we have to take into account the impact of climate change and climate change policies. Climate change might increase agricultural production if the increase in temperature is less than 2% and might lead to lower production if the increase in temperature is higher (OECD, 2009). Climate change policies might reduce responsiveness of agricultural supply and lead to higher food prices. Policies aimed at reducing greenhouse gas emissions such as CO_2 taxation and restriction on land use related to carbon storage might increase consumer prices.

[1] Figures advanced by Professor John Beddington, UK Government Chief Scientific Advisor, at the Symposium *An Agrarian Renaissance?* held at the James Martin 21st Century School, Oxford on 2 July 2009 (http:www.21school.ox.ac.uk/).

The expected impact on world prices of the 10% EU-biofuel directive and the various global biofuel initiatives is depicted in Figure 3.19 below (Banse et al., 2008a). If all initiatives are implemented together and technological change stays on the historic trend, then the impact on world prices is substantial and the long term trend of declining world prices in the reference scenario might be dampened or reversed. The arrival and impact of second-generation biofuels is uncertain. According to Banse et al. (2008a), biofuels lead to higher agricultural income, land use and land prices, and a loss of biodiversity.

Figuur 3.19 **Change in real world prices, in percent, 2020 relative to 2001**



Source: Banse, M., et al. (2008).

Development of oil prices is crucial for the development of biofuels. Some experts point that prices stay high due to increased demand in Asia and depleting supply resources. Others indicate that this is a temporary situation as capacity is lacking at the moment due to too few investments in the past. If oil prices stay high, food and energy markets will be more interlinked. The oil prices will then put both a floor and a ceiling[1] for prices in the food markets (Schmidhuber, 2007). As energy markets are large and more elastic, the long-term trend of declining food prices might be changed (less negative to positive dependent on the development of the oil price).

High feedstock prices make biofuels less profitable (ceiling effect), as does a low oil price (floor effect). At the current level of crude oil prices of USD70 per

[1] Ceiling price effect: as feedstock costs are the most important cost element of all (large scale) forms of bioenergy use, feedstock prices (food and agricultural prices) cannot rise faster than energy prices in order for agriculture to remain competitive in energy markets. Floor price effect: if demand is particular pronounced as in the case of cane-based ethanol, bioenergy demand has created a quasi intervention system and an effective floor price for sugar in this case.

barrel, no biofuels are economically viable without policies. A low oil price implies that only biofuels will be produced under mandates or that they are heavily subsidised. Without an increase in oil prices the impact of biofuels is therefore limited to the impact of filling the mandates.

The interrelation with the energy markets may slowdown or reverse Cochrane's treadmill or Owens development squeeze which imply declining real agricultural prices, less farmers, larger scale farming and possible depopulated areas.

Volatility of world prices might be an important problem in the future that causes hunger in terms of very high prices for poor consumers and problems for poor farmers when prices are low. The ceiling and especially the floor may act as an intervention price in case of very volatile prices. A floor may also stimulate agriculture in the (poor) world. Hunger is not a problem directly related with biofuels but often of bad policies, and improperly functioning factor and commodity markets.[1] In principle, there is enough food in the world but there is a distribution problem.

Rising food commodity prices tend to negatively affect lower income consumers more than higher income consumers. First, lower income consumers spend a larger share of their income on food. Second, staple food commodities such as corn, wheat, rice, and soybeans account for a larger share of food expenditures in low-income families. Third, consumers in low-income, food-deficit countries are vulnerable because they must rely on imported supplies, usually purchased at higher world prices. Fourth, countries receiving food aid donations based on fixed budgets receive smaller quantities of food aid. A simplified comparison of the impact of higher food commodity prices on consumers in high-income countries and on consumers in low-income, food-deficit countries illustrates these differences (see Table 3.3).

This illustrative comparison shows that for a consumer in a high-income country a 30% increase in food prices causes food expenditures to rise 3% (€1,200), while for a consumer in a low-income country food expenditures increase by 15 percentage points.

[1] IAASTD (2008, p.5), 'Policy options for improving livelihoods include access to microcredit and other financial services; legal frameworks that ensure access and tenure to resources and land; recourse to fair conflict resolution; and progressive evolution and proactive engagement in Intellectual Property Rights (IPR) regimes and related instruments.'

Table 3.3	Impact of Higher Food Commodity Prices on Consumers' Food Budgets	
	High income countries	**Low income, food deficit countries**
Initial Situation		
Income	€40,000	€1,000
Food Expenditure	€4,000	€500
Food Costs as % of Income	10%	50%
30% increase in food prices		
New costs for total food expenditure	€5,200	€650
Food Costs as % of Income	13%	65%
Source: Own compilation.		

3.6 Concluding remarks

The analyses shows that the price increases have several roots and that a normally functioning market will in time provide a certain degree of corrective action (the invisible hand of Adam Smith). But policy/political decisions can prevent the market from doing so. In any case, the time lapse for the market to act does not remove the acuity of the price distortion that affects the poorest people and urgent intervention is necessary to alleviate the effects of short-term price peaks.

In the long run tension on the agricultural markets remains as population and income growth continue and non food demand might increase if oil prices increase. Our analyses indicates that a long term recession or decline in GDP growth has severe impacts on agricultural markets.

The influence of policy/political decisions mentioned above is certainly present when considering why food production in many countries is below the potential capacity. Not only has land been voluntarily removed from production in some cases, but the access to technology and markets is sometimes also limited by factors that are strictly in the realm of governance. But then there are also potential producers, who simply can not make it into the market, and they can be assisted through micro-credit or through the donation of tools, seeds and the development of irrigation, storage capacity and transportation facilities to integrate into market structures.

Our further observations are of several orders, and theses are with regard to policy implications, market failure, social equity, and required policy action.

Policy implications

With regard to the EU, CAP reform was designed to enforce farmers' reaction to market signals. There should be no surprise, therefore, when farmers do, and therefore production falls close to the level of world demand. The problem, however, is the time lag between the demand in the market and a farmer's decision on what - and how much - to plant. There is always some degree of 'inadequate' response on the supply side. Around the world, farmers are now responding to price signals and are increasing their production of cereals. Building up and managing stocks is not the primary responsibility of farmers and in a free market this is left to traders; some government intervention might be considered, but a return to automatic intervention based solely on commodity prices should be absolutely avoided!

Will current price level persist?

High prices can only be 'cured' by high prices. This may initially seem to be a provocative statement, but the simple fact is that - as stated above - farmers do react to price signals. So do all the other agents in the economy, including speculators! Prices are now down again but still above their 2000-2007 level. The food price 'crisis', be it too high or too low prices, will certainly be prolonged through protective measures by national governments. The issue of civil stability may encourage some governments to take such actions, to reassure their populations that 'something is being done'. Biofuels and other biomass demand to substitute for fossil energy, however, create a more direct link between food and fuel prices and if fuel prices increase further, the long-term trend of declining real food prices might be dampened or reversed. However, in the long run new technologies (use of green algae and cyanobacteria as a source for ethanol, bio-diesel and biogas for example, as well as for the production of hydrogen[1]) might be an alternative fuel source, and therefore could dis-

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[1] It is far more efficient to maximise the solar energy conversion efficiency by 'harvesting' it before it is accumulated in vegetal biomass. In the advent of cellulosic conversion, a massive use of biomass could also result in the same type of resource depletion in the future as now occurs for fossil fuels, if exploitation would be more rapid than the biological rate of replenishment. In fact, plants do not use their entire potential for photosynthesis; but in any case energy is lost at each step in the formation of complex biomolecules, limiting the potential role of genetic engineering. (M. Tikkanen et al., 2009).

place crop-based bio-ethanol and bio-diesel, and decoupling between agricultural and energy prices would occur. This possibility has to be clearly taken into account in commodity projections, in order to correctly inform the policy formulation for the agricultural sector, as biofuel production as a source of demand may eventually become more modest in scale (biomass in one form or another will undoubtedly remain an input into energy production: e.g. combined heat and power units).[1]

Who is mostly affected?
The consumers of food in low-income countries with food and energy deficits are those who will suffer most in any sudden or rapid price increase for basic commodities, of which foremost is food. In principle, high prices provide additional income opportunities for farmers. Whether farmers in developing countries will benefit from high prices on world food markets remains questionable and depends on the degree of integration of regional markets in global food markets. But if there is no structural market failure involved *per se*, as stated above, then this means that the conditions of productivity and market access are the priorities that have not been addressed successfully for a long period of time *before* a price crisis occurs.

Required policy action
Short-term action is to urgently increase spending on food aid in case of a food crises as in 2008. Long-term production capacity improvement (including publically financed agricultural research) is essential to avoid repeated price crises and to deal with the expected tension on the agricultural markets in the long run. However this is not just simply doing basic R&D and farm modernisation, but also additional spending in investment in human capital stock (education), extension services, chain efficiency and improvements in market institutions (governance). The 2008 food crisis was not a crisis in terms of shortage of food, but a crisis in terms of income shortage (in terms of purchasing power and of investment potential to increase productive capacity). Policy measures should enable especially the poor to be able to participate in the economy and therefore for the poor countries to generate income within a world market.

[1] On the horizon of 2015, nevertheless, world ethanol demand is expected to be between 130 and 149 bln litres. (International Sugar Journal, Vol CXI, No 1323 (March 2009), p. 155)

The challenge for society

In the long run an enormous challenge will be how to feed the world and fight climate change at the same time. On the one hand, agricultural demand is growing rapidly due to population and income growth and high oil prices might create an enormous non-food demand as biomass inputs might substitute for fossil fuel inputs. On the other hand, more and more restrictions on supply might be introduced to fight climate change. The impacts of especially climate change policies are not well known. To fulfil both aims will be an enormous challenge for society and both institutional and technological innovations are necessary.

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