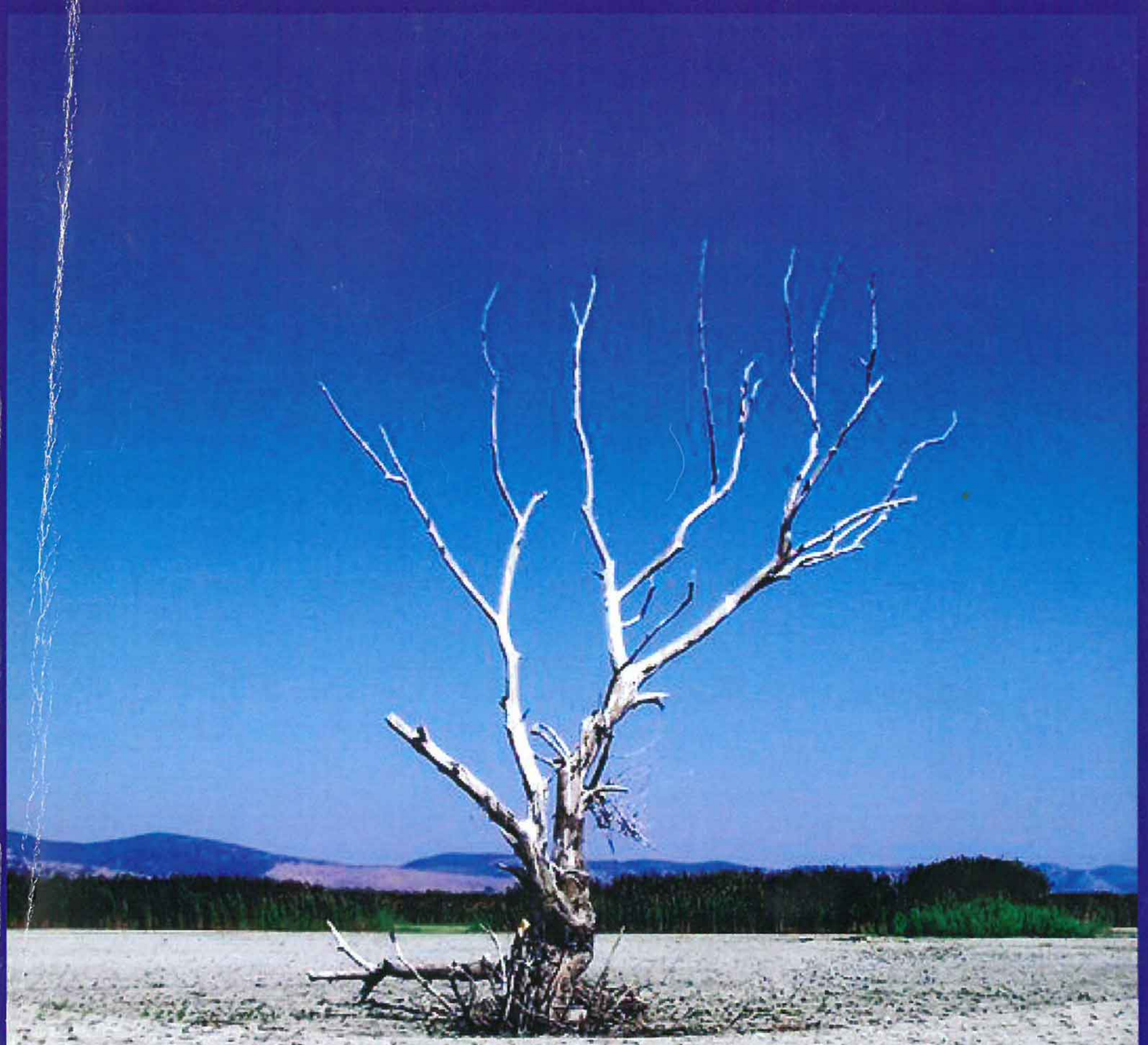


GLOBAL CLIMATE CHANGE

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AGRICULTURE AND ENVIRONMENT RELATIONSHIP WITH SPECIAL ATTENTION TO GLOBAL CLIMATE CHANGE

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Abstract

Environmental problems related with agriculture practices are actual issues in many countries. These problems are emerged from different type of agricultural activities. There are increasing focuses on the contribution of agricultural practices to climate change. Agricultural sector follows energy and industrial sectors by means of greenhouse gas emissions. Greenhouse gas emissions have been increased especially from the 1990's due to mechanization, energy demand and technological progresses. Intensive agricultural inputs like fertilizers, manures, pesticides, hormones, antibiotics etc. and fossil fuels are getting more used for agricultural production incrementally. Agricultural production systems have been developed by mechanization, pesticides, fertilizer and productive varieties. These developments led to an increase in energy consumptions at the same time. Beside being a pollutant factor to environment, agriculture, is also the most affected sector from other activities especially from industrial wastes, transportation, mining, tourism activities, urbanization etc. Environmental pollution, especially for soil and water, reduces agricultural yield and causes product losses. The objective of the study is to explore the categories of agricultural activities and input usage which increases the greenhouse gas emissions. Also, it should be discussed how to protect agriculture from climate change with alternative regulations.

Key Words: Agriculture, input usage, global climate change.

Introduction

It could be said that agriculture sector has a complex structure because of the fact that it's connected to nature and climate conditions and it covers plant production, animal husbandry, fishery products and land using. Thus there's a multidimensional connection between the agriculture sector and global warming. The period from agricultural production to consumption and reproduction contributes the global warming in different levels and it can be affected positively or negatively. According to the long-term researches results, the impact of global warming to agriculture won't be experienced equally in every part of the world and it won't be the same. For instance, because the elongation of growing seasons connected to the temperature increase eases the forms of photosynthesis, it's expected that the yield of cereals and potatoes will increase. However, there's a possibility of yield loss in agricultural products due to temperature rises and drought in other parts of the world and because of that situation, starvation may occur. Intensive farming systems are generally responsible for highest emissions of greenhouse gases in agriculture while some low input farming systems in

marginal areas are the most affected ones by climate changes[1,2]. This situation shows that by affecting the product prices, there will be socio-economic inequality in the world and the balance of trade will be in favour of the northern countries where efficiency increase is expected.

To make the agricultural production sustainable, the environmental impacts of agricultural inputs used in production and consumption period (seeds, fertilizers, pesticides, etc.) and energy resources (transport and heating purposes) should be evaluated and alternative solutions should be discussed. It's necessary that the agricultural and environmental policies, integrally, should include measures to adapt agriculture to climate change and should be turned in a way that precautions can be taken to reduce greenhouse gas emissions.

In this study, methodologies, literatures, reviews where the previous studies are examined and classified, study findings obtained from secondary data, and finally, policies of reducing climate change caused by agricultural activities are aimed to be discussed.

Methodology

This study is a literature study created with the help of articles and reports including the relationships between climate change and agriculture. In this study, secondary data, models and projections created for present and future are utilized.

Literature Review

The impacts of climate change to agriculture and the impact of agriculture to climate change are assessed as a result of joint efforts of different disciplines. Another study field directly connected with agriculture is the impact of climate change on natural resources. About all these subjects, it can be said that a rich literature has been created especially for recent years. A portion of the work has been prepared by obtaining data for many years as field work. Another part has been built by statistical models and projections related to future periods with the help of available data.

The most comprehensive publications written for relations between climate change and agriculture are as a result of international level summits, meetings or projects. Recently, in the report dated 2007 by Intergovernmental Panel on Climate Change (IPCC) prepared with the contributions of Smith et.al.(2007)[3], it has been explained that how agriculture effects climate change and in what level and how they could be affected.

In a more recently submitted publication, the results of various statistical models and projections are explained in Food Climate Research Network (FCRN) website. Consultative Group on International Agricultural Research (CGIAR) published a program with the Vermeulen et. al., (2012)[4] team about 'Climate Change, Agriculture and Food Security'. United States Environmental Protection Agency (EPA) released U.S. Climate Action Report in 2010 describing the agriculture sector about this subject in national and international level. Furthermore there are studies of EPA conducted jointly with the IPCC. In the book co-written by Organization for Economic Co-Operation and Development (OECD) member countries,

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[1] Olesen and Bindi, 2002, p.1-2.

[2] Schils et.al., 2007, p.501

[3] Smith et.al., 2007,

[4] Vermeulen et. al., 2012, 198-200.

Wreford et. al. (2010)[5], in parallel with climate change, is describing the state of agriculture today and in future with international comparisons and explaining IPCC projections. The document of Development of a Farm-Level Greenhouse Gas Assessment project by Arctic and Antarctic Research Institute (AARI), is giving technical information about the greenhouse gas emissions.

There are plenty of studies too which is not connected to the institutions mentioned above and dealing with a single subject in agriculture. About the impact of animal husbandry on climate change there are studies of McMichael et.al (2007)[6], Watson et.al (2001)[7], Smith et.al (2007)[8]. About the economical impacts and costs, Adams et.al.(1998)[9], Parry et.al (2004)[10] and Tol (2001)[11], and about social impacts Fisher et.al. (2005)[12], Morton (2007)[13] and Hertel and Rosch (2010)[14] have studies. Agriculture also has considerable potential to mitigate climate change through sequestering GHGs. About the mitigation potential of agriculture in climate change, there is a journal called "Journal of Mitigation and Adaptation Strategies for Global Change". Moreover, in this subject, there are studies of Cooper et.al. (2013)[15], Verge et. al., (2007)[16], Howden et.al (2007)[17] and others. Since climate change effects on natural resources are crucial for agriculture there are many comprehensive studies which is not mentioned due to the limits of the study.

Research Findings

Agriculture and climate change relation can be categorized in three groups. Greenhouse gases from agriculture, climate change impact on agriculture and agricultural mitigation potential for climate change (Smith et.al., 2007[8]; Dellal, 2008[18]).

A. Greenhouse gases from agricultural sources

The contribution of agriculture to total food system emissions is from 7,300 to 12,700 $MtCO_2e$ (Million metric tons of carbon dioxide equivalent) per year. It's about 80% to 86% of food systems emissions and 14% to 24% of total global emissions. Land use changing is also very important, because it is ranked second in the total global emission list. About 75% of emissions from land use change are attributed to agriculture[4].

The emissions throughout the agricultural supply chain differ from product to product and from system to system. For instance, if you take a product in the form of raw tomatoes, the process of tomato from farm to our kitchen may change according to the region, tomato

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[5] Wreford et. al., 2010, p.79-80.
[6] McMichael et.al., 2007,
[7] Watson et.al, 2001,
[8] Smiths et.al., 2007, p.519.
[9] Adams et.al., 1998, p.19.
[10] Parry et.al., 2004, p.53.
[11] Tol, 2001,
[12] Fisher et.al., 2005,
[13] Morton, 2007,
[14] Hertel and Rosch, 2010,
[15] Cooper et.al. ,2013, p.221.
[16] Verge et. al., 2007, p.255.
[17] Howden et.al., 2007
[18] Dellal, 2008, p.1.

variety, farming system, production scale, and transportation conditions and finally reaching to the consumer. For this reason, estimated numbers and ratios can be given by making some assumptions in calculations. Because the agricultural production is structurally heterogeneous and depending on natural conditions, essential production processes are included in emission calculations.

i. Livestock production and red meat consumption

Livestock production, which has an impact on climate change, negative health consequences including the threat to food yields, is about 20% of total greenhouse gas emissions. The contribution of nitrous oxide and methane to climate change should be considered too. Recently, the methane gas has been evaluated that its contribution to climate change is more than half that of CO_2. Another threat for high emissions is global meat consumption. Climate change can directly affect livestock. The link of stress factors on livestock appetite like high temperature can be given as an example. We can see an indirect influence of climate changes in the requested modification of the quantity. Furthermore it can be seen on the quality of forages from grasslands and the supplies of concentrates[19].

Animals provide not only food, but also non-food goods such as leather, manure, wool etc. Therefore, production of non food animal based products should be taken into account for calculating CO_2 emissions[20].

ii. Deforestation, land degradation, peat land and rice production

Emissions from deforestation, forest degradation and peat land degradation are calculated in different studies. These sources of greenhouse gases account for 12%-14% of total. Peat land degradation has also been found serious in these studies [3,5].

Also, where there is water stress and/or heat stress, the world's cereal crops shall become vulnerable to even minor changes in temperature. Temperature changes, precipitation changes and increases in the atmospheric concentration of CO_2, have an impact on all crops[21].

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[4] Vermeulen et. al., 2012, p.195.
[19] Watson et al., 2001
[20] Garnet, 2009
[4] Vermeulen et. al., 2012, p.198-200.
[21] Wreford, 2007.p.79.

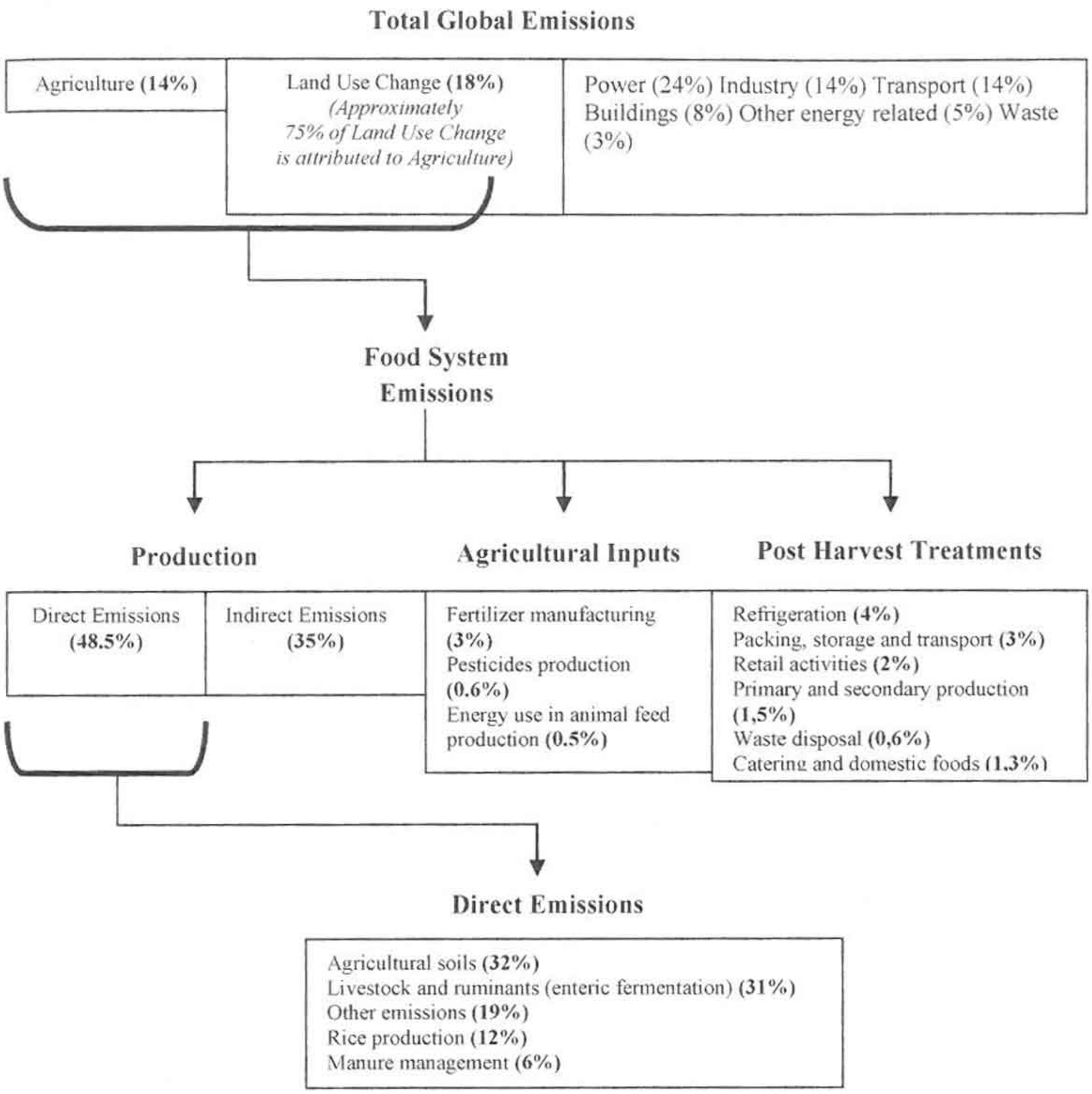


Figure.1. Greenhouse gases from agricultural sources[4]

B. Possible climate change impacts on agriculture

Agricultural activities are mostly affected by climate. The changes in climate have impacts on crop and livestock production, hydrologic balances, input supplies and other agricultural system components[9].

a. Food security: Crop response-yield variability

Climate change has a direct impact on food production and increases food security and malnutrition threats[22]. Even though how the agricultural product yields are affected by climate changes cannot be calculated precisely, some predictions can be made by models and scenarios.

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[9] Adams et.al., 1998, p.22.

[22] FAO, 2011, p.1

Agriculture products differ in terms of temperature range needs for a healthy growth within their life cycle. For plant growth, there's an optimum temperature that the plant can grow as fastest as possible. Which varies depending on the species, the temperature that increases until the optimum degree, generally, speeds up the plant growth by life-cycle phases. When this optimum temperature is exceeded, growth slows down[23].

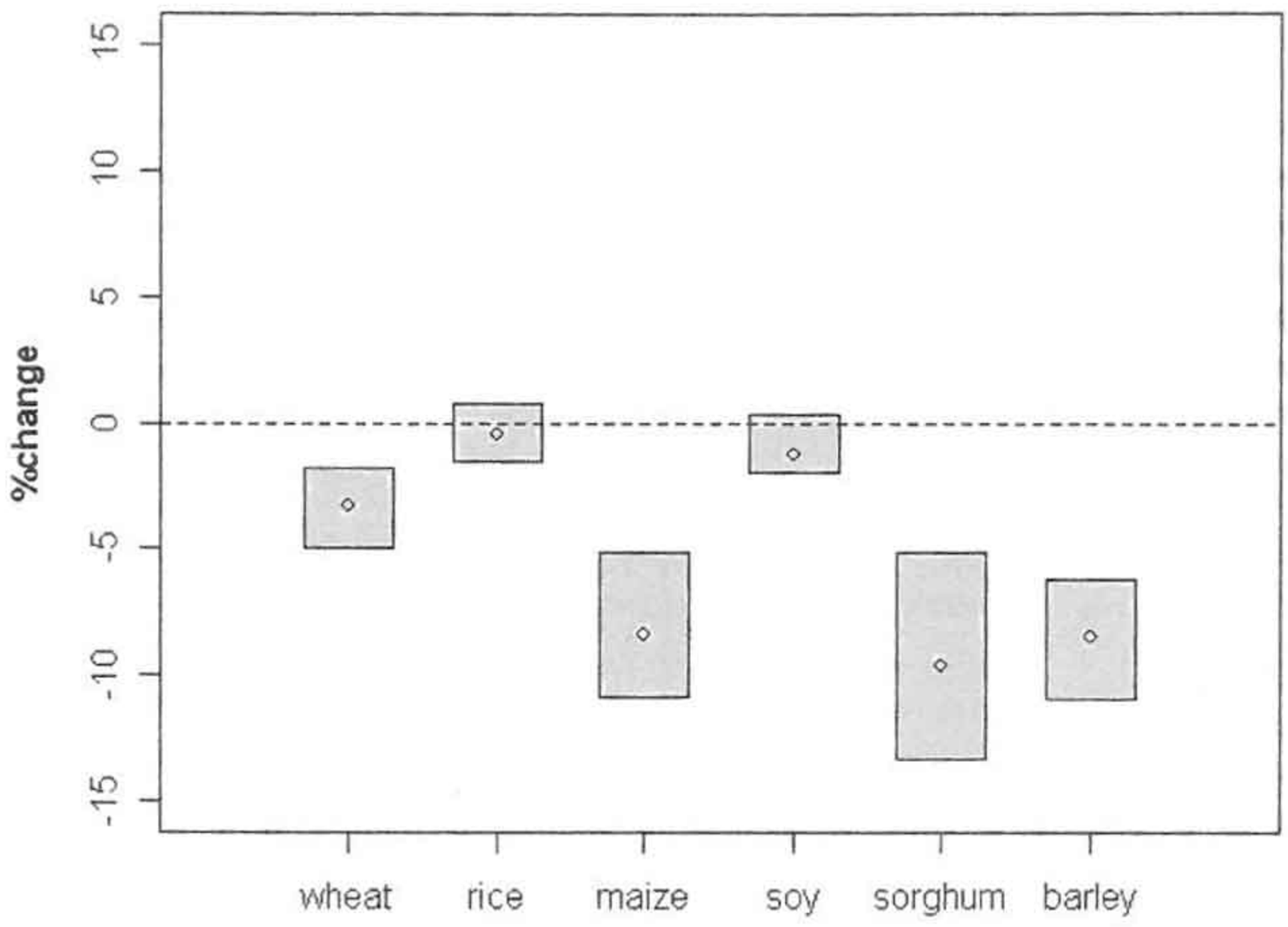


Figure 2. Yield change in % for warming of 1°C[24]

Parry et.al. (2004)[25] discovers a production function model in his study. He inspects the effects of climate change on product yield with different models and scenarios. Mostly, the SRES scenarios lead to crop yield increases in developed countries and yield decreases in developing countries. With expected losses up to 30%, decreases are very important in Africa and in some parts of Asia. An apparent response of global yields to high temperatures is observed for barley, wheat and maize. Having these sensitivities and climate trends, we can predict that warming starting from 1981 has led to annual combined losses of these crops standing for approximately 40 Mt or $5 billion a year, as of 2002 (Figure 2)[24]. As these impacts are not much relative to the technological yield incomes over the same period, the results represent negative impacts of climate trends on crop yields at the global scale[24]. According to Howden et.al. (2007)[26], climate could have subsequent impacts on agricultural structure. For example, El Nino Southern Oscillation phenomenon, with its associated cycles of droughts of flooding events, had changed the global yield in wheat, oilseeds, and coarse grains.

b. Food safety and nutrient losses

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[23] Anonymous, 2013. (tarim.gov.tr http://iklim.tarim.gov.tr/Tarimkarbon.html)
[24] Field, 2013; Lobell and Field 2007.
[24] Field, 2013; Lobell and Field, 2007
[25] Parry et.al., 2004, p.66.
[26] Howden et.al., 2007

Food safety and its issues are related with each other. Unacceptable or poor standards of food safety that cause improper food for human consumption, will also impair food security. This situation may force people to consume foods that are of lower quality or contaminated, or that have reduced availability of certain minerals and nutrients[27].

The other problem arises from incremental pesticides usage. The disease is affected by the changes in UV-B, CO_2, and ozone levels. It modifies the physiology and resistance of the host. Changes in temperatures, precipitation and the frequency of extreme events will also affect the disease epidemiology. The relative importance and spectrum of diseases are modified by the geographical distribution changes. This may lead to new disease complexes. Increased fecundity in elevated CO_2 and/or enhanced UV-B radiation may speed up the evolution of pathogen populations. Consequently, resistance of hosts may be overcome quicker. Disease management will be affected from altered efficacy of biological and chemical control options[28]. It's predicted that the changes in temperature and precipitation due to global warming will lead to epidemic diseases in agricultural products and excessive increases in pests and weeds, therefore pesticide usage will increase. Because the yield will decrease due to temperature rises, it's expected that more pesticide usage will be necessary in order to protect existing products[29]. Furthermore, according to Pimentel (2008)[30], increasing pesticide usage and lavish use of petrochemical resources may result in the reduction of non renewable resources. So, this situation will increase the possible risks for environment and human health. Also for economical aspects, the pesticide usage increases the product costs. More pesticide usage and improved or genetically modified seeds against diseases increase the production costs of producers and making the producers dependant to the products of big companies.

Besides pesticides, excessive chemical fertilizer use for plant production may different environmental problems beside threat water, soil conditions and food safety. It also increases the concentration of bioactive nitrogen compounds in the global environment[31]. The main source of GHG emissions is fertilizer production, largely owing to its energy intensity but also to some emissions of nitrous oxide (N2O) in the manufacture of nitrate fertilizer[7]. Agricultural N2O emissions are projected to increase by 35-60% up to 2030 due to increased nitrogen fertilizer use and increased animal manure production[3,32].

Climate change eases the spread of some diseases out of their environmental systems. For instance, malaria-carrying mosquitoes will go to the northern hemisphere and at the same time they will speed up the erosion of biodiversity. A review published in 2004 explained that the climate change will lead to the disappearance of 5% of living organisms[33].

C. Agricultural mitigation potential

In agriculture, mitigation and adaptation interact with each other simultaneously. But they differ in their spatial and geographic characteristics. In terms of climate change, benefits of

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[27] M.Miraglia et.al. 2009, p.1009.
[28] Chakraborty et.al., 2000
[29] Sik, 2013, p.1-2.
[30] Pimentel, 2008
[31] McMichael et.al. 2007
[32] FAO, 2003
[33] Kempf, 2010
[3] Smith et.al., 2007, p.500

mitigation actions will emerge over decades. But if other policy objectives are achieved, short-term benefits may be observed. On the other hand, enhancing adaptation to climate change impacts will have consequences in the short and long term. For future climate change, most mitigation measures like nutrient management will presumably be powerful, whereas a subset will probably be weak (e.g., irrigation in regions becoming more arid). As the climate changes, a vulnerable practice can be modified and the efficacy of a mitigation measure can be maintained (low agreement, limited evidence)[3].

While climate change mitigation efforts increase, to prevent greenhouse gas emissions, cheaper ways should be identified[34]. There is no universally applicable list of mitigation practices. The proposed practices need to be evaluated for individual agricultural systems according to the specific climatic, edaphic, social settings and historical land use and management. For non livestock mitigation options, mitigation potentials per unit land area for different climate regions (cool–dry, cool–moist, warm–dry, warm–moist) can be defined[3]. For livestock options, mitigation potentials for CH4 from enteric fermentation can be defined for different livestock groups in different regions. In the following sections entitled 'GHG mitigation potential in global agriculture', 'GHG mitigation potential in European agriculture' and 'GHG mitigation potential in UK agriculture', the mitigation potential of agriculture at global scale, European scale and for the UK, is outlined[35].

Organic agriculture can help in mitigating greenhouse gases by farming practices which create soil fertility, avoiding synthetic fertilizer usage and improving carbon sequestration. Organic farmers replace synthetic fertilizers with biomass management. It provides both soil fertility and increased soil carbon sequestration. In the report of IPCC, there are many techniques packed into organic management as relevant mitigation and adaption actions. These actions are the integration of leguminous plants into the crop rotations, ideal soil cover, mixed farming systems and the longevity of ruminants[23]. Flessa et.al (2002)[36], explained that the conversion from conventional to organic farming resulted in reduced emissions per hectare farm and field area, but yield-related emissions were not reduced. Thus, the conversion to organic farming may contribute to the reduction of greenhouse gas emissions from agriculture, if agrarian policy strives to reduce the intensity of agricultural production.

There is a risk that farmers may be reluctant to adopt greenhouse gas mitigation techniques unless they improve profitability. On the other hand, certain techniques have already been adopted for reasons other than climate change concerns. These are no-till agriculture or strategic fertilizer placement and timing. Using proposed mitigation options for mitigation of CO2, CH4 and N2O increases crop and livestock productivity. At least, it improves efficiency of input usage without decreasing yield[37]

Conclusion

Although the impact of climate change on agricultural activities includes uncertainties, it has been trying to be predicted by the studies. The common point of these studies is that the estimated effects won't be at the same strength throughout the world. As it's in the other

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[34] Burney et.al, 2010
[3] Smith et al., 2007
[35] Smith, 2012.
[23]FAO, 2011.
[36] Flessa et.al, 2002, p.187.
[37] Cole et.al., 1997.

environmental problems, economical development level of countries and to what extent the economical activities (including agriculture) increase the climate change are questioned too. Precisely, the thing which is responsible for this problem is trying to be found. However, only knowing that 'which activity increases climate change and how much' is not enough to solve the problem. The unique discourse is needed to shape the common future of humanity. In this instance, within the scope of policies, in case there's an economic interest of countries or multinational corporations; it may not be easy to carry out action plans.

Neale (2008)[38] argues that there is enough technology in the world to stop the global warming and to use these technologies appropriately; governments should find a solution to this problem in global level by making public works, regulations and heavy spending. Specifying that the governments should act more than companies, Neale emphasizes the public importance of the problem with his words "Governments can do what the markets cannot do because the governments don't need to profit". Therefore, market based solutions are not ebough for the agricultural mitigation. Agri-environment schemes have the potential to support many adaptation initiatives like Common Agricultural Policy cross compliance measures.

Humanity is concerned about not only the food security issues but also the status of facing hunger especially in the least developed countries after many years. For instance, especially in Europe, it has become almost a fashion to buy product from local producers due to environmental pollution and climate changes. A consumer group has been formed saying "consume your local product even it's not organic" and their domain is steadily expanding with the social networks. In that case, the devoloping trade of agriculture products and the changes in agricultural production structure, should be discussed more.

In agriculture sector, the initiatives to reduce global warming have came to a point that their control cannot be given to an individual. The revision of agricultural policy instruments to be applied for this purpose, and better consideration of the fields related to environment and climate change issues while maintaining the producers' income levels, are needed.

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[38] Neale, 2008, p.40.

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