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ARTICLES

Ethics and Biofuel Production in Chile

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Abstract Chile needs to diversify its energy supply, and should establish policies that encourage the production and use of biofuels. The demand for energy resources increases with population growth and industrial development, making it urgent to find green alternatives to minimize the impacts of greenhouse gas (GHG) emissions of traditional fuels. However, it is required that sophisticated strategies consider all externalities from the production of biofuels and should be established on the basis of protecting the environment, reducing GHG emissions and to avoid violating human rights. This article presents the Chilean reality, based on ethical principles that should be guarded to regulate the bioenergy market. These principles are: (1) human rights, (2) environmental sustainability, (3) climate change mitigation, (4) right to a fair reward, and (5) equitable distribution. It is concluded that in Chile the concentration of land and water for the development of extractive industries; and for agricultural and forestry purposes, contradicts the principle of human rights. The unequal distribution of income is also highlighted as part of a cycle of social injustice, with a high Gini coefficient (0.52). However, the policy of biofuels can be strengthened with the early use of second generation feedstock, the introduction of fair trade and regulation by the state to encourage participation of small farmers, and allows a position for Chile at the forefront of bioenergy production.

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Introduction

Chile imports 60.2 % of its energy supplies, including 94.1 % of oil, 93.7 % coal and 80.3 % of natural gas consumed (Ministerio de Energía 2013), making it a dependent country in the international fuel market. The country's inability to meet its energy needs with their own resources is an opportunity for the state to take over energy security, based on a multidimensional concept, defined from the economic, political, and territorial (Becalli et al. 2009).

The composition of the Chilean energy matrix, with a high component of fossil fuels (Ministerio de Energía 2013), involves pollution, environmental degradation and redistribution of economic resources abroad (Gebremedhin et al. 2009). In recent years it has prompted the use of non-conventional renewable energy (NCRE), by technological advancement and reduction in installation costs as well as increased social demand by a pollution free environment (Demirbas 2009; Gebremedhin et al. 2009).

Biofuels help ensure energy security (Paneque et al. 2011), but Chile has no binding rules of use, and/or production on a commercial or industrial level. The country imports fossil oil to meet its energy needs (García et al. 2010), and thus encourages debt, rising inflation and the devaluation of the exchange rate (Kiatmanaroch and Sriboonchitta 2014). Biofuels can prove to be a solution to reduce dependence on foreign energy and promote economic development (Paneque et al. 2011). The energy crossroad where Chile stands, demands decision by the State, how to bet quickly, decisively and unequivocally for biofuels, which are the only viable alternatives to the use of fossil fuel.

Chile is lagging in the production and use of biofuels (García et al. 2010). Most countries in the region have adopted legislation for the promotion of industry, research, development and innovation for process optimization and control of mandatory use (Janssen and Rutz 2011). Currently, the regulatory framework for biofuels in Chile can be summarized in the following standards: Circular 30/2007, the Internal Tax Service (SII) of Chile, which states that biofuels are not subject to the specific tax on fuels (SII 2007); Law 18,502/1986 of the Ministry of Finance, which decrees the chemical nature of biofuels is different from diesel oil and gasoline (Ministerio de Hacienda 1986); Decree 11/2008, of the Ministry of Economy, Development and Reconstruction, which defines the quality specifications for biodiesel and bioethanol, and authorizes the mixtures of 2 and 5 % with petroleum diesel and gasoline, respectively, also announces the registration of persons and institutions marketed biofuel in the Superintendence of Electricity and Fuels (SEC; Ministerio de Economía, Fomento y Reconstrucción 2008); Law 20,339/2009, of the Ministry of Finance amending Decree-Law 1/1979 of the Ministry of Mining (Ministerio de Minería 1979), incorporating biofuels as liquid fuels and empowers the SEC for audit (Ministerio de Hacienda 2009); Exempt

Resolution 746/2008 of the SEC, which sets technical standards for analysis and/or testing for bioethanol and biodiesel (SEC 2008).

State participation is essential to define the economical, technical, social and environmental conditions for the establishment of Biofuels (Buyx and Tait 2011). Chile shall demand biofuel mixes for the marketing of fossil fuels, so it will be necessary to establish a legal framework for their development. The legal framework should respond to the mix of biofuels or specifications, and a treatment in accordance to the development of the bioenergy industry. Objectives of biofuels can only be achieved with comprehensive, flexible and long-term policies (García et al. 2010).

Biofuel production has positive and negative impacts on biodiversity and the environment (Goldemberg et al. 2008; Demirbas 2009; Renouf et al. 2010; Nuffield Council on Bioethics 2011), benefits highlight the security and diversity of the agricultural industry, reducing emissions of greenhouse gases (GHG), and reduced uncertainty about energy dependence of fossil fuel in importing countries (Demirbas 2009; Nuffield Council on Bioethics 2011). In addition to being primarily from plant origin and renewable, allows a steady supply of raw materials, especially in rural and remote areas (Demirbas 2009).

However, they also have a history of negative externalities of bioenergy production (Goldemberg et al. 2008; Koh and Wilcove 2008; Janssen and Rutz 2011; Renouf et al. 2010). The deforestation in the Amazon despite having no direct relation to the production of biofuels is affected indirectly by increasing soybean crops and sugar cane, for the empowerment of land for grazing and by the change of land use (Goldemberg et al. 2008; Janssen and Rutz 2011). Other environmental and social effects are caused by the burning of sugarcane in Brazil (Janssen and Rutz 2011; Renouf et al. 2010) or biodiversity loss by the conversion of tropical forests for palm oil production in Indonesia and Malaysia rainforest (Koh and Wilcove 2008).

Large-scale production of biofuels, and marketing, will take many years to become established as a competitive industry in Chile (Paneque et al. 2011). Governments should encourage policies that promote research and ethical production of biofuels according to social development and international treaties of biodiversity, and climate change. The Nuffield Council on Bioethics, to avoid or combat social conflicts, proposed five ethical principles that should be considered for the development of bioenergy industry, takes place in sustainable conditions (Nuffield Council on Bioethics 2011).

Five basic ethical principles that should be insured through policies and certificates, according to the Nuffield Council on Bioethics (Nuffield Council on Bioethics 2011) are: (1) development of biofuels should not be at the expense of human rights; (2) biofuels must be sustainable; (3) biofuels should contribute to reducing GHG emissions; (4) biofuels should adhere to the principles of fair trade; and (5) the costs and benefits of biofuels should be distributed equitably.

Principles of ethical production of biofuel are intended to prevent production problems of first generation biofuels are maintained long term (Tait 2011). In this paper we assess the situation in Chile for the production of biofuels, even though there is no established market, and the current state is analyzed according to five ethical principles proposed by the Nuffield Council on Bioethics (Nuffield Council on Bioethics 2011)

Biofuel Ethics

Use of food crops and/or land for energy production is one of the main ethical conflicts that has arisen in the production and use of bioenergy, particularly biofuels (Koh and Wilcove 2008; Gomiero et al. 2009). Ethical concern is a growing discussion in the areas, political, social, economic and academic-university, whether bioenergy production is truly sustainable (Nuffield Council on Bioethics 2011).

In recent years, this conflict has been extensively addressed (Koh and Wilcove 2008; Gomiero et al. 2009; Buyx and Tait 2011; Macer 2011; Mortimer 2011; Nuffield Council on Bioethics 2011; Tait 2011; Thompson 2012), and have established the principles and/or ethical, human rights, environmental sustainability, climate change mitigation, the right to fair and equitable reward distribution to be considered in biofuel production (Table 1). However, when these ethical principles are met, and production of biofuels contributes to climate change mitigation, a sixth principle is established, which is the duty to develop biofuels (Nuffield Council on Bioethics 2011; Tait 2011).

Table 1 Ethical criteria established for the production of biofuels

Criteria	Desciption
Human rights	The production of bioenergy and biofuels should not violate the rights and liberties of individuals. The main duties are to preserve: access to food and water, health and labor rights and access to land
Environmental sustainability	Biofuel production should provide environmental benefits and ecosystem services to society and the environment. Under this criterion should avoid excessive production of energy crops, especially in developing countries, which can cause changes in land use (direct and indirect), clearings of land, loss of biodiversity, excessive water use and increased pollution from the use of fertilizers or pesticides
Climate change mitigation	The production and use of biofuels, assist reduce GHG emissions to the atmosphere. For this, it is necessary to develop methods of certification, to corroborate that indeed there is a reduction in emissions. In this way the effects of changes in land use that increase GHG emissions, a situation that has been brought into question the sustainability of biofuels are avoided. In this case, the life cycle analysis appears to be an effective tool for this posting
Right to a fair reward	Biofuel production should be done under fair trade criteria, giving them opportunities for development and competition from producers. Fair trade is also focused on working practices, where they must respect labor and intellectual property rights
Equitable distribution	Costs and benefits -environmental, social, economic or political- of biofuels should be distributed equally among all producers and users

Source Nuffield Council on Bioethics (2011)

Biofuels can provide benefits or prejudice to the society and the environment (Antizar-Ladislao and Turrion-Gomez 2008; Demirbas 2009; Buyx and Tait 2011). The effects of the utilization of energy crops can have on society and environment depend on crop, production processes that are used to treat raw material, and political and economic constraints that are established (Nuffield Council on Bioethics 2011). The discussion regarding the benefits and prejudices of biofuels should not focus solely on an anthropocentric view of the effects, but to consider all the visions of bioenergy production from the ecosystem, providing value, not only to effects that may be caused to human beings but to the planet as a whole (Macer 2011).

Ethical Principles Applied in Chile

Principle 1 Human Rights

Available information on human rights in Chile is mainly related to the violation of human rights that occurred during the military dictatorship (1973–1990), and have been focused on the integrity and freedom of individuals (Loveman 1998; Garrido and Intriago 2012). Violations of human rights in Chile, at the 2013, are part of conflict by the free exercise of democracy, equal access to justice, criminalization of abortion, physical and psychological violence against children and women, situations of discrimination on specific groups of people (e.g. indigenous groups, immigrants and transgender) and access to basic goods and services such as housing, work, and for the first time, access to water is discussed (CDH 2013; INDH 2013). Particular attention has had the existing dispute between indigenous communities and the government, the right to land, ancestral rights, and equal justice and access to water (CDH 2013; INDH 2013). The rights of access to land and water, and equal justice are those that can have the greatest impact on the production of biofuels in Chile, as shown in the following subsections.

Indigenous Villages and the Right to Land

The indigenous and Mapuche worldview, in general, establishes that land is not necessarily individual, but collective, based on traditional uses they have performed historically and the spiritual and material identity they have with their territory (CIDH 2010; INDH 2013). Indigenous people do not value land as a productive and economic entity, but as a collective property right and can be enjoyed freely (OIT 2009). It should clarify and, where possible, restore those lands that are considered indigenous, that there is delineation of territory, and to avoid conflicts over their use and exploitation of natural resources that take place (INDH 2013).

An example of conflict over land ownership in indigenous territories is what happens in the so-called "Mapuche territory", south of the Biobío River. After the coup d'état in 1973, the Mapuche territory was handed over to private hands (CHR 2003) and the Decree-Law 701/1974 that encourages forest plantations (Ministerio de Agricultura 1974), the Mapuche lands were used, and are currently used in forest production (CHR 2003). The main plantations of radiata pine (*Pinus radiata*) and eucalyptus (*Eucalyptus sp*.) are concentrated in the regions of Biobío and Araucanía (Paneque et al. 2011), precisely the “Mapuche territory”. Forest plantations of radiata pine and eucalyptus, total over 94 % of those existing in Chile (ODEPA 2010), and have the potential to be used in the production of biofuels (Román et al. 2012).

The conflict between the Chilean state and the Mapuche people generates political instability by use and ownership of land (CHR 2003; INDH 2013), and can affect the production of biofuels. Exploitation of natural resources for the production of energy crops, in Mapuche territory, requires a solution to their demands and establishes ownership of territories as a strategy to move forward, ethically, when used for production of biofuels.

Concentration of Land

Agricultural and forestry census in Chile in 2007 found that there are 29.78 million with farms and 6.66 million ha with forestry. Of total surface farms, 20.74 million ha are distributed among 1430 owners, i.e. that 69.64 % land with agricultural potential belongs to 0.51 % owners. While 9.04 million ha (30.36 %) remaining is distributed to 277,230 (99.49 %) owners (INE 2007), which accounts for the high level of concentration possessed. According to Echeñique (2011), despite the concentration of land with farms, 75 % of these lands are distributed in end regions of the country, regions from Arica and Parinacota to Coquimbo and Aysén and Magallanes, territory with a low agricultural and forestry potential.

In Chilean forestry sector, there possesses 3.27 million ha commercial farms (INE 2007). Out of the total exploitations, 53 % (1.8 million ha) belong to the two major forest companies in Chile, Forestal Arauco (Celco) and Manufacturing Company Paper and Cardboard (CMPC), which also show a high concentration in the area (INE 2007; Echeñique 2011; Paneque et al. 2011). The concentration of land, to a lesser extent, is also present in other areas. Seed companies have between 35,000 and 45,000, which generally have a high dependence on some transnational (INE 2007). The philanthropist Douglas Tompkins has about 300,000 ha in the Chilean Patagonia for conservation purposes (Echenique 2011, Gómez 2011). Generally, the concentration of land has been made at expense of smallholders, who are unable to compete with large producers productively, and in many cases, they are obliged to sell their land to these same producers (Echenique 2011).

Water Rights and Concentration

Property and market of water resources may have implications in production of biofuels. The main duties are to preserve access and control of water (CDH 2013; INDH 2013). Its concentration, distribution, and use of the resource should be analyzed under Chilean legislation granting rights to water use, i.e. Water Code (Ministerio de Justicia 1981).

In article 5 of the Chilean Water Code states that “waters are national public goods” and that “individuals are granted the right to use them” (Ministerio de

Justicia 1981). Water rights in Chile are granted free and in perpetuity, it is not necessary to explain what purpose in which these resources (Valenzuela et al. 2013) were used, which implies a separation of land and water use (Ríos and Quiroz 1995; Bauer 1997).

Politics of water distribution in Chile determined the creation of a water market, where speculation and hoarding of rights deprived of possibility of new productive activities that require water for development are implemented, since it is not necessary to define a particular use, nor show whether used or not (Dourojeanni and Jouravlev 1999). When all the water rights in a basin are given, this is declared depleted, so only way to get access to water is through acquisition of these rights, through the buying and selling in the water market. Marketing of water rights does not necessarily take place, because until 2005 there was no legislation to regulate use of water (Bauer 1997; Dourojeanni and Jouravlev 1999; Solanes and Jouravlev 2006; Valenzuela et al. 2013).

The amendment of the Water Code Law 20,017/2005 (Ministerio de Obras Públicas 2005) allows the state to charge a patent for non-use of water rights acquired and sought to solve existing legal gap, speculation and hoarding of rights water (Solanes and Jouravlev 2006; Valenzuela et al. 2013). New water rights are granted according to needs of projects, so it has a use established, and rights can be limited according to public interest of water (Solanes and Jouralev 2006).

The patent for non-use of water rights has not been effective in solving problems of distribution of water rights, and since it took effect in 2007 income from non-use of patent have increased from million US $ 16.9 in 2007 to million US $ 21.0 in 2009 (Valenzuela et al. 2013), and is expected to raise the amount for 2014 to be million US $ 78.0 (DGA 2013). The constant increase in the license fees for non-use water rights are greater than the costs of those who own the rights to have the financial support to pay the patent for non-use, so it restricts and disables the execution of new projects using water. (Valenzuela et al. 2013).

Conflict over ownership of water is an important country-level issue in this, especially in the northern regions of Chile, where water rights have a high value for water scarcity (Oyarzún and Oyarzún 2011; Valenzuela et al. 2013). Precisely in the north of Chile is where it is possible to develop energy crops, mostly agricultural land without value, where there are conflicts over water use between mining and agricultural activity (Oyarzún and Oyarzún 2011; Molina 2012). Conflicts with indigenous communities and their ancestral water rights are also present (Molina 2012). Productive activities mining, agriculture and energy are important for development of the country, which should exist in harmony and minimizing conflicts between them.

Principle 2 Environmental Sustainability

In Chile there is no commercial production of biofuels, so it does not register conflicts with this principle. However, consider the scenarios for future development of bioenergy industry in the country and how to potentially occur. To comply with the principle of environmental sustainability it is important to consider

Table 2 National area by regions, with different levels of erosion in 1979 and 2009 (thousand ha)

Region	Area	IREN-CORFO (1979)					CIREN (2010)				
		0	1	2	3	Total	0	1	2	3	Total
Arica y Parinacota	1685.55	38.75	1027.38	1116.08	356.77	2538.98	583.59	468.75	171.56	255.73	1479.63
Tarapacá	4225.58						838.36	1153.19	601.63	1047.23	3640.41
Antofagasta	12,602.37	0.00	1435.20	1120.14	126.25	2681.59	2021.38	3592.83	3242.12	1370.59	10,226.92
Atacama	7566.51	1056.25	152.25	809.25	630.38	2648.13	629.08	2029.94	536.64	825.22	4020.88
Coquimbo	4059.51	0.00	654.25	1425.69	1370.61	3450.55	492.36	1213.86	1142.37	571.64	3420.23
Valparaíso	1599.96	51.10	231.79	146.83	463.95	893.67	79.97	258.17	324.56	244.25	906.95
Metropolitana	1540.59	95.23	387.79	58.75	17.10	558.87	186.79	213.45	189.45	93.36	683.05
O'Higgins	1638.34	198.38	544.43	210.62	19.92	973.35	114.53	196.77	453.59	96.29	861.18
Maule	3034.03	152.41	662.37	686.59	36.65	1538.02	335.79	377.76	416.09	349.00	1478.64
Biobío	3712.05	175.69	818.49	1167.53	200.44	2362.15	148.62	211.57	429.06	393.41	1182.66
Araucanía	3186.35	65.84	809.39	1533.32	69.54	2478.09	145.85	243.92	240.87	280.46	911.10
Los Ríos	1837.41	401.96	593.37	1655.91	2194.87	4846.11	5.84	79.59	197.56	262.31	545.30
Los Lagos	4833.74						33.27	138.92	423.46	574.69	1170.34
Aysén	10,796.66	145.25	909.88	2179.50	1389.88	4624.51	583.36	383.08	743.45	894.66	2604.55
Magallanes y Antártica	13,207.11	0.00	900.00	3463.50	524.25	4887.75	761.47	589.97	1288.59	1122.85	3762.88
Total	75,525.76	2380.86	9126.59	15,573.71	7400.61	34,481.77	6960.26	11,151.77	10,401.00	8381.69	36,894.72

0 very severe erosion, *1* severe erosion, *2* moderate erosion, *3* light erosion

[a] In the year 1979, the regions of Arica y Parinacota and Tarapacá, belonged at region of Tarapacá; and the regions of Los Ríos and Los Lagos, belonged at region of Los Lagos

availability of land and type of raw material used for producing biofuels (Zhuang et al. 2011).

The availability of land is one of the most important limiting factors for the production of bioenergy (Zhuang et al. 2011). In Chile, there is approximately 5.0 million ha with agricultural potential, and if we consider land with livestock and forestry potential, it would provide 25.2 million (ha) (Casanova 2000). In connection with Latin American countries, Chile does not have enough land to produce biofuels on a large scale (Paneque et al. 2011). In Brazil, for example, 23 million ha were used, in 2010, only for soybean production (Garret et al. 2013), while the total land agroforestry potential exceeds 310.5 million ha (IBGE 2006).

Chile requires policies that regulate the conversion of agricultural land with potential for production of energy and raw materials and should search using poor quality soils, and to revalue depressed territories and optimize production according to local conditions. Use of marginal lands can provide sustainable energy (Zhuang et al. 2011), but should also be considered, which are lands with high erosion risk or environmental fragility (Kang et al. 2013).

Chile has 36.8 million ha with different levels of erosion, representing approximately 48.6 % of the mainland (CIREN 2010). Soil degradation has remained stable over the past 30 years, as in 1979 were 34.5 million ha reported with different levels of erosion (IREN-CORFO 1979). However, this increase of 2.4 million ha eroded occurring mainly in the categories very severe and severe, registering a 57.4 % increase in land erosion at these levels (Table 2).

In northern Chile, in regions between Arica and Parinacota and Coquimbo, representing 39.9 % of the country, the highest levels of erosion are recorded (CIREN 2010; Zulantay et al. 2013). This area has 75.6 % of the total area eroded, the most serious in the Region of Arica and Parinacota, where 87.8 % of its territory, is with some level of erosion event (CIREN 2010; Zulantay et al. 2013). However, in the south of Chile, in the regions of Los Lagos and Aysén, representing 20.7 % of the national territory, respectively have 24.2 and 24.1 % of its surface eroded (CIREN 2010).

Enabling degraded marginal lands is an alternative for production of biofuels, thereby limiting conversion of agricultural land for energy production. Process of conversion of land use should be made by selection of crops and cultural practices that promote recovery, or at least diminish the erosive processes that they affect (Ellies 2000; Ravindranath et al. 2011). Use of energy crops and corresponding technologies for second and third generation biofuels may represent a possible and desirable option for producing biofuels ethically (Cai et al. 2011; Demirbas 2011).

Between the main raw materials used globally for production of liquid biofuels are palm oil (*Elaeis guineensis*), soybeans (*Glycine max*), rapeseed (*Brassica napus*) and sunflower (*Helianthus annus*) for biodiesel (Thoenes 2007; Paneque et al. 2011); and corn (*Zea mays*) and sugarcane (*Saccharum officinarum*) to ethanol (Goldemberg et al. 2008; Janssen and Rutz 2011). Palm oil, among species used, is the only one that does not have as its primary purpose a food use, but its establishment and production in countries like Indonesia and Malaysia, has been made on the basis of change in land use, direct and indirect, to detriment of populations of native forests (Koh and Wilcove 2008).

Raw material available, and which has established biofuel production, comes from traditional agricultural crops or species where production processes are based on conventional technologies, and are called first generation (Antizar-Ladislao and Turrion-Gomez 2008). Biofuel production of second and third generation feedstock base employ crops that do not have agricultural importance, and that do not compete with them for territory (Table 3). Also including macro and micro cultures where advanced technological processes are used, of third-generation (Antizar-Ladislao and Turrion-Gomez 2008; Gressel 2008; Demirbas 2009, 2011).

As previously mentioned, Chile has no commercial production of biofuels, though different species have been evaluated as potential raw materials. Rapeseeds and sunflower appear as major oilseeds for biodiesel production in the country (CATA 2007; Iriarte et al. 2010), while wheat cereals (*Triticum aestivum*) and corn are the main raw materials for ethanol (Cavieres 2006; CATA 2007). Second-generation oilseeds have also been studied for biodiesel production, such as jatropha (*Jatropha curcas*; Zulantay et al. 2013), guindilla (*Guindilia trinervis*; San Martín et al. 2010), castor (*Ricinus communis*) and spurge (*Euphorbia lathyris*; Zapata et al. 2012) and camelina (*Camelina sativa*; Berti et al. 2011; Solis et al. 2013). Other potential raw materials with a lower level of study are tarweed (*Madia sativa*), Chilean palo verde (*Geoffroea decorticans*), prickly poppy (*Argemone mexicana*), and micro and macroalgae (Garcia et al. 2010; Román et al. 2012).

Studies to promote raw materials for ethanol production in Chile are limited and have focused on feasibility analysis of lignocellulosic material used as the main input for the production of second-generation ethanol. Among the species tested include radiata pine and silver wattle (*Acacia dealbata*; Muñoz et al. 2007; Araque et al. 2008) On the other hand we have considered use of biomass corn “Luteño” (*Zea mays* amylacea type), which is tolerant to saline soils and excess boron (Bastías et al. 2011) variety, and underground biomass forage turnip (*Brassica*

Table 3 Biofuel classification, by origin and technological processing of the raw material

Generation	Description	Example
First generation	Biofuels from traditional energy crops (sugar, starch and oilseed) and animal fat	Ethanol: corn, wheat and rice Biodiesel: rapeseed, sunflower and soybean
Second generation	Biofuels from non traditional energy crops (sugar, starch and oilseed); from perennial grasses, agricultural and forestry wastes and lignocellulosic species	Ethanol: switchgrass (*Panicum virgatum*) and sweet sorghum Biodiesel: jatropha and castor bean
Third generation	Biofuels from micro and macro algae. It is used most advanced technology for processing and production	Ethanol: *Chlamydomonas reinhardti* and *Chlorococcum littorale* Biodiesel: *Oedogonium sp*. and *Spirogyra sp*.

Source: Antizar-Ladislao and Turrion-Gomez (2008); Gressel (2008); Hossain et al. (2008); Beer et al. (2009); Demirbas (2009) *rapa*), under a dual purpose production system, it is intended to employ leaves for animal food and roots as raw material for ethanol (CORFO 2009). Macroalgae (*Gracilaria chilensis* and *Macrocystis pyrifera*), have also been tested, but still should improve productive technologies for development (Aitken et al. 2014).

The Development Corporation of Chile Production (CORFO) during 2008 and 2010 supported creation of five consortia aimed biofuels of second and third generation. These consortia, which are focused on use of lignocellulosic material (Biocomsa and Bioenercel), microalgae (Desert Bioenergy and Algae Fuels) and macroalgae (Bal Biofuels) are comprised of public, private and academic entities. Investment made through CORFO and private agents totaled million US $ 44.1 (CORFO 2008, 2010).

Principle 3 Climate Change Mitigation

Life cycle analysis provides information on the effect of biofuel production on climate change (Iriarte et al. 2010). The calculation of carbon footprint and energy balance, also provide information, although these methodologies lack evaluation methods, and deliver varying results, so they are not certifiable, and are not considered as productive tools to compare alternatives (Farrell et al. 2006; Pandey et al. 2011). Comparison and certification of carbon footprint of biofuels can be performed with the ISO 14,067 standard, which is focused on the quantification and subsequent communication of carbon footprint of products obtained (www.iso.org)

In Chile the study of life cycle analysis of agricultural production for energy purposes, rapeseeds and sunflower indicates that the cultivation of sunflower is between 1.2 and 39 times the impact on environment than rapeseeds. Net energy analysis indicates that ratio of output/input energy is 5.0 and 3.5 for rapeseeds and sunflower, respectively (Iriarte et al. 2010). Other results show that net energy of agricultural production is 5.4 to rapeseeds in till and 3.7 for sunflower (CATA 2007). Net energy for agricultural production is 4.9 for rice, 4.6 for corn and 4.4 for wheat (CATA 2007).

However, when calculating net energy considers agricultural production, and process of transformation of biomass into energy efficiency 2.1 for rapeseed in zero tillage and 1.9 for sunflower, for production of biodiesel is estimated; and 1.2 for irrigated wheat, 1.3 for rice and 1.4 for corn, for ethanol production (CATA 2007). The results indicate that use of rapeseeds is more energy efficient for production of biodiesel and corn for ethanol production.

Life cycle analysis of third generation ethanol using macro algae (*G. chilensis* and *M. pyrifera*) shows mixed results for energy efficiency. When ethanol is produced, multiple macro algae present energy efficiency near 1.0. However, when used in a system of biorefinery for production of ethanol and biogas, energy efficiency reaches values close to 3.0 for *G. chilensis* and 2.0 for *M. pyrifera* (Atkin et al. 2014).

Life cycle analysis and net energy show that the main problems for their contribution to climate change mitigation, are given for efficient use of fertilizers, use of toxic herbicides and use of farm machinery, and consequent consumption of fossil fuels due to cultural practices (Iriarte et al. 2010). Use of nitrogen fertilizers, usually impacts the assessment of GHG emissions and net energy (CATA 2007; Iriarte et al. 2010), and is the main contributor to eutrophication and acidification of the medium (Iriarte et al. 2010, 2011).

Principle 4 Right to Just Reward

Fair Trade

It is trading partnership based on dialogue, transparency and respect that seek greater equity in international trade. It contributes to sustainable development by offering better trading conditions to, and securing the rights of marginalized producers and workers, especially in the southern hemisphere (WFTO 2009).

In Chile the fair trade operations are limited; however the national wine industry has made some transactions (Mori and Malo 2003). The possibility of marketing a manufactured product, instead of raw material, such as wine, favors and is in line with the principle of fair trade, as it leaves most of the gains in producing country. Mori and Malo (2003) analyzed the situation of two wine cooperatives and one private equity firm, with the 3 members of the Organization of Northern Trade Fair.

Participation in a fair trade organization delivers benefits and safety partners (Rosas-Baños 2013). The wine industry in Chile established contracts of sale prior to harvest, technical assistance and support in a cash advance, allowing vintage tackle better, especially for small producers. Contracts set the selling prices of raw material, which is not directly related to market prices of grape, but depend on sales price of final product, i.e. of the wine. Producers obtain more benefits by marketing directly to vineyards, where the latter set purchase prices. Fair trade ensures that members of cooperative, who are to be grape growers, have ensured the production and marketing of its vintage (Mori and Malo 2003).

The National Program for Production and Use of Biodiesel in Brazil (PNPB) represents the idea of fair trade that is required for production and commercialization of biofuels (La Rovere et al. 2011). One of the main lines of social inclusion PNPB is where the marketing and use of biofuels production cooperatives and small farmers is favored (César and Batalha 2010). Family farming is the main source of raw materials for production of biodiesel and receives tax advantages to encourage trade in biofuels. Biodiesel companies must buy at least a percentage of production of small farmers, an amount that is regulated by the Ministry of Agrarian Development of Brazil, which varies by region in refinery is located (César and Batalha 2010; La Rovere et al. 2011). The program provides social PNPB seal (Social Fuel Seal) for production of biodiesel (Tait 2011).

Intellectual Property

You can protect rights and benefits that come with a new invention or process (Tait 2011). Biofuels can also be affected by this principle as conventional breeding, through selection of varieties or ecotypes, and genetic engineering, can provide in optimizing the development of new varieties or ecotypes, and production processes granting property rights who obtained them (Antizar-Ladislao and Turrion-Gomez 2008).

Decree-Law 3/2006 on Intellectual Property in Chile limits, through article 37 b, the patenting of plants and animals (Ministerio de Economía 2006). New plant varieties can only have rights of breeders as Law 19,342/1994 article 3, which delivers exclusive authorization to its developer, for their production, sale, marketing and employment, and must have the authorization of the breeder to make benefit of new variety. Article 7 of Law 19,342/1994, provides that if the breeder incurs unfair or monopolistic practices, delivery is feasible for licensing use of new variety as considered Seed Department, under the Agricultural and Livestock Service (SAG; Ministerio de Agricultura 1994).

In Chile, genetically modified products are not regulated and cannot be traded; however, the country is a world leader in production of genetically modified seed varieties, but only for export (Salazar and Montenegro 2009).

Principle 5 Equitable Distribution

Within Latin America, Chile has the highest per capita income (US $ 19,511 projected by 2016 International Monetary Fund 2013) and the best Human Development Index (HDI 0.819 to 2013; PNUD 2013), although distribution of income, according to the Gini index shows a high level of inequality (Valenzuela and Duryea 2011).

The Gini coefficient of inequality, which gives a “0” to the absolute equality and “1” to absolute inequality (Medina 2001), for Chile is 0.52 in 2011 (CEPAL 2014), being above average in Latin America and the Caribbean (0.50; World Bank 2014). Inequality in Chile, in contrast to other countries in the region, where despite having much lower Gini Chilean—e.g. Uruguay, 0.38; Venezuela, 0.41 or Argentina with 0.44—(CEPAL 2014; World Bank 2014) present indicators of HDI and per capita income lower than Chile, and higher levels of poverty (PNUD 2010, 2013).

Uruguay has historically been a country with one of the best Gini coefficient in Latin America (PNUD 2010; Valenzuela and Duryea 2011), but you can see that by removing 2 % of the wealthiest populations in both Chile and Uruguay, the gap in the Gini coefficient, in 2006, for the per capita income between the two countries is shortened in Chile and Uruguay from 0.56 to 0.45 to 0.47 to 0.41, respectively (Valenzuela and Duryea 2011). Consequently, and despite that Chile has made progress in overcoming poverty over the rest of Latin America, 10 % of the richest population receives 47 % of income, while the poorest 20 % only 3.4 % (Sanhueza and Mayer 2011). Income inequality contradicts the principle of equitable distribution in production of biofuels, and would not produce a fair distribution of profits (Buyx and Tait 2011).

Distribution of wealth in Chile, accounting retained earnings by companies or capital gains, which are not recorded in the statement of income taxes, show a strong concentration of wealth. The statements of income tax made by individuals in 2010 in the Internal Tax Service (SII) of Chile, 1 % of the population accounted for 14.6 % of revenue, not including retained earnings or capital gains, which implies that 1 % of the population earn 40 times more than 80.6 % of the population with

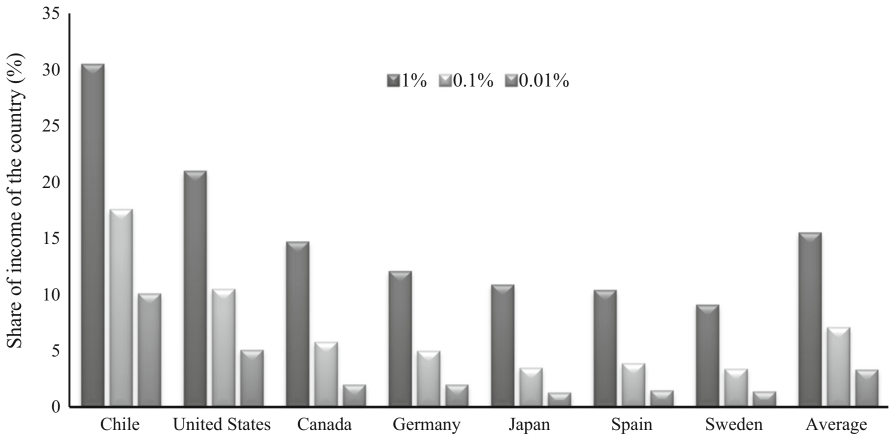

Fig. 1 Comparing the share of total income of the country for the 1, 0.1 and 0.01 % of the richest population, including capital gain (López et al. 2013)

the lowest income. When retained earnings and capital gains are incorporated, 1 % of the population account for 31.3 and 30.5 % of revenues for retained earnings and capital gains, respectively. This analysis shows that when considering retained earnings and capital gains, the Gini index reaches 0.63 for Chile, further accentuating problems of income distribution (López et al. 2013).

Comparing Chilean situation, considering the capital gain, with other countries if the capital gain is incorporated in the analysis of income distribution, high concentration of wealth in Chile is appreciated. 1 % of the population accounts for 21 % of wealth in the United States, 14.7 % in Canada and 9.1 % in Sweden, while in Chile reach up to 30.5 % (Fig. 1; López et al. 2013).

To protect and promote equitable distribution of costs and benefits of biofuel production, there must be state policies that allow the harmonious development of this industry. The principle of distribution should focus not only from an economic but also social and environmental perspective. It should also keep in developing countries bear costs of foreign policy in production of biofuels (Tait 2011). Buyx and Tait (2011) described that through conversion of land for food to fuel, which can occur in poor countries producing biofuels, developing countries and importers of biofuels, will receive benefits such as increasing energy security and climate change mitigation.

Conclusion

Chile can reduce its dependence on fossil fuels internationally and has the opportunity to improve their geopolitics of energy security indices. It is required to establish and enforce ethical principles, to be at forefront of technological and productive bioenergy production. The state should promote policies that encourage investment strategies in an emerging economic area, and that includes protecting the natural, social and cultural heritage as well as the safety of workers and labor practices.

The ownership and concentration of land and water is one of the main obstacles for the development of bioenergy industry. Amend existing legislation on water rights and access to land is a process that requires political will, and may be delayed in coming. Mechanisms should be found to enable the development of bioenergy industry and minimize impacts of problems arising from control of land and water (Table 4).

Bioenergy industry should ensure food security and avoid competition between food and fuel. Brazil and PNPB should be example to standardize and regulate production of biofuels in Chile. Energy policy should consider the active participation of small farmers and small farming, the main actors of the production of raw material. The sustainability of the industry should be established under the principles of fair trade to ensure that production of raw material complies with standards of fairness (Table 4).

Chilean bioenergy industry should consider manufacturers and use of second generation feedstock, enabling degraded areas which are not required by agricultural or forestry production. (Table 4) Crop production to support biodiesel industry requires evaluation and deepening existing studies on new productive alternatives available, e.g. castor, Chilean palo verde, guindilla, and jatropha. Ethanol industry has and must be set on use of agricultural and forestry residues, and represents an opportunity for Chile because of its availability and prospects for technological development. The stimulus to innovation and research will find productive

Table 4 Actual situation for biofuel production from an ethics perspective in Chile

Criteria	Actual situation in Chile
Human rights	The main problem is with land and water concentration. Distribution of land in Chile it is unequal, where 69.64 % of territory belongs at 0.51 % owners. Furthermore, the water market in Chile allows speculation and hoarding of the rights, complicating the access a new users
Environmental sustainability	Chile do not have industrial production of biofuel, therefore do not exist conflicts with this principle. To future is possible the biofuel production, but this is should performed using second-generation of raw material
Climate change mitigation	Life cycle analysis for biodiesel production from rapeseed and sunflower in Chile, demonstrated than sunflower have more environmental impact than rapeseed, while than net energy for rapeseed and sunflower were 5.0 and 3.5 respectively. For ethanol net energy were 4.9 for rice, 4.6 for corn and 4.4. for wheat. However it is necessary to prove second and third generation of raw material, because these crops have a better environmental performance
Right to a fair reward	There are experience of fair trade in Chile, even though are for wine industry is could apply for biofuel industry, as PNPB in Brazil. Intelectual property for bredding of plants is not possible in Chile, but its developer has the authorization for its production and comercialization
Equitable distribution	The unequal distribution of income is considered as part of cycle of social injustice, where the Gini coefficient (0.52) is higher than another Latinamerican countries with worst economic development

alternatives to approach the ethical principles, and thus positioning Chile as a sustainable biofuel producer.

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