Int J Life Cycle Assess (2018) 23:1429–1447
DOI 10.1007/s11367-015-0932-5

Responsible sourcing of metals: certification approaches for conflict minerals and conflict-free metals

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Received: 30 June 2015 / Accepted: 6 July 2015 / Published online: 4 August 2015

Abstract
Purpose Responsible sourcing of metals is characterized as an approach for life cycle management (LCM) and sustainable supply chain management (SSCM) of social issues. The focus is on the supply of "conflict minerals"—tin, tantalum, tungsten, and gold (3TG)—whose mining and trade are implicated in conflict and severe social conditions in the Democratic Republic of the Congo (DRC). Downstream manufacturers are using compliance strategies to reach multiple tiers and long distances into product chains to buy conflict-free sources of these metals from mines, smelters, and refineries.
Methods The research uses qualitative methods and public documents to compare 16 conflict mineral programs. A theoretical framework in three dimensions guided the enquiry into program governance, program standards, and certification processes. Additional empirical analysis of the conflict-free sourcing program, the largest and most central industry-led effort on conflict minerals, was supported by confidential access to audit reports, company policies, and management procedures on more than 140 metallurgical facilities.
Results and discussion In fewer than 4 years, conflict-free sourcing programs have impacted global 3TG metal supply chains, as indicated by pricing and significant producer compliance. Electronics, jewelry, and other manufacturers—many influenced by US conflict mineral regulation—are "pulling" metals markets for conflict-free sourcing. Private standard programs focus on product chain chokepoints to support efficient engagement: a limited number of 3TG facilities that are influenced to implement "responsibility management systems," practice conflict-free sourcing, and undergo compliance audits. Some supply chains operate as closed pipelines along the full product chain from mine to end-product. Tantalum has been most successful as about 95 % of producers are compliant; however, for gold, in particular, the scale of compliance is challenged.
Conclusions Downstream manufacturing industries are "governing at a distance" the management practices of upstream raw material producers. For LCM, responsible sourcing may be applicable to product chains with other metals and commodities. For SSCM, conflict-free sourcing indicates how compliance and supplier development strategies can penetrate multiple tiers into supply chains to address social issues in developing countries. Future research is needed on understanding more on supplier companies and their motivations and on sustainability performance outcomes for the conflict mineral problem.

Keywords Auditing · Certification · Conflict minerals · Governance · Metals · Mining · Raw materials · Responsible sourcing · Social aspects · Standards · Sustainable supply chain management

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1 Introduction

Various tools and methods are used to manage product chain sustainability, from analytical techniques, like life cycle assessment (LCA), to broader business approaches, like sustainable supply chain management (SSCM). Life cycle

management (LCM) is related to both LCA and SSCM but is not as well studied or understood in terms of approaches and implementation (Nilsson-Lindén et al. 2014). Moreover, there is a paucity of knowledge on the social dimension of sustainability within research and practice relating to both SSCM (Seuring and Muller 2008; Yawar and Seuring 2015) and LCM. The present research seeks to address this gap by looking at responsible sourcing of metals, which addresses social issues across multiple tiers in international product chains.

A wide variety of raw materials and resources are certified on consumer labels for sustainability performance or origin. However, the list is dominated by biotic commodities derived from renewable resources: wood, cotton, palm oil, coffee, fish, cocoa, and other foods and fibers. The present research examines how sustainability standards and certification are used in business-to-business contexts to manage the production of nonrenewable resources: metals and minerals that are used in manufactured products. This is elaborated by looking at programs and practices largely by the electronics industry to responsibly source four metals—tin, tantalum, tungsten, and gold—the so-called "conflict minerals," collectively referred to as "3TG." The social issue of concern is severe humanitarian problems and the financing of warfare from the illegal mining and sale of the conflict minerals in the eastern Democratic Republic of the Congo (DRC) in the Great Lakes Region of Africa. Government, NGO, and corporate responses to the conflict mineral problem have been ongoing since 2008 (Young et al. 2010). Because of the use of 3TG metals in their products, the global electronics industry, in particular, has responded to the social issue and identified the use and sources of 3TG metals, in cooperation with multiple other industries worldwide. By developing so-called "conflict-free sourcing," electronics manufacturers and other downstream industries collaborate to manage the product chain of raw materials supplied from all 3TG sources across the world. The conflict-free sourcing program (CFSP) specifically has used standards and third-party audits since 2010 to assess management systems and material purchasing activities at smelters and refineries in more than 25 countries to assure that their sources of 3TG metal feedstocks are "conflict-free." Compounding the social issue, a new law in the USA, created as part of the Dodd-Frank financial reforms act (US Securities and Exchange Commission 2010), requires publically traded companies on US stock exchanges to report on their use of conflict minerals. Between legal requirements and voluntary industry efforts around the world, there are widespread activities to identify and confirm origins and manage sources of 3TG metals.

Using an inductive, qualitative research strategy, the research employs a social science framework to compare governance, standards, and certification across 16 programs that address the conflict mineral problem. The CFSP, which is the largest of these programs and the central industry effort, is examined in greater detail.

1.1 Objectives

The present research aims to characterize responsible sourcing as an approach used in LCM. The object is to examine the structure and operation of certification of raw materials and explore strengths, weaknesses, and opportunities of certification as a mechanism for responsible sourcing. The research looks specifically at the conflict-free sourcing of minerals and metals as an area where a social issue associated with raw material supplies is managed.

1.2 Contributions

This study makes a number of contributions. The conflict mineral issue is a large and unique area of corporate social responsibility and product sustainability that is new to the extant literature. The study characterizes responsible sourcing as a tool for LCM and SSCM. Empirically, it provides understanding of the structure and mechanics of standards, assurance, and certification used in complex manufacturing supply chains. The paper presents four findings that advance understanding of SSCM and LCM: (1) downstream companies are using market forces to "pull" for changes in practices at producers that are multiple tiers upstream in the product chain, (2) collaborations between parallel programs and between companies along product chains are supporting outcomes, (3) by targeting "chokepoints" in material life cycles, responsible sourcing supports certification efficiency, and (4) the use of management system standards allows for large-scale LCM of raw materials. Responsible sourcing has the potential to provide substantial amounts of compliant materials to global markets, without a continuous connection along the product chain from raw material to end-products.

This paper is presented as a scholarly contribution to sustainability management. In the next section, the extant literature is briefly examined to define product chain management approaches and clarify key concepts. The theoretical framework used in the research is then outlined, as are the methodology and data are used. Then results of the 3TG programs are reviewed, including a detailed description of the CFSP, and a snapshot of progress made in conflict-free sourcing is provided. The study's main analysis follows, as findings are discussed and connected to the broader context, and to LCM and SSCM. The paper concludes with mention of research limitations and ideas for future study.

2 Background

2.1 Approaches for sustainability management of product chains

Life cycle assessment (LCA) is indirectly concerned about the origins of resources and materials, as provenance may influence study results. Responsible sourcing is about better understanding raw materials, which, incidentally, is an area that is poorly characterized in life cycle impact assessment (Gemechu et al. 2014). In this paper, "source" refers to the processes by which a material is produced; metal sources include mining, recycling, historical sources (such as government stockpiles), and intermediate by-products from processing other metals (such as gold by-product from copper refining). "Origin" is a deeper concept and refers to the geographic location from which a resource is originally extracted or created. Metals are originally mined, whereas the origin of recycled material is usually unknown. Origin is rarely accounted for in LCA studies and is not well captured in LCA databases, although it may be present in environmental product declarations or labeling. Production profiles of materials from different sources may vary significantly. Origin might also have a significant influence, since ore-type and process technology change from location to location.

LCM and SSCM are management approaches that aim to improve the environmental sustainability of products, goods, and services (Table 1). Like LCA, these methods are also extended to consider social and economic attributes in sustainability management of product chains. The approaches are similar but provide different perspectives and are rooted in different traditions (Nilsson-Lindén et al. 2014). The United Nations Environment Programme (UNEP)/Society for Environmental Toxicology and Chemistry (SETAC) Initiative describes LCM as a broad concept referring to the systematic use of management concepts, tools, and programs applied along the product chain to improve sustainability (environmental, economic, and social) dimensions of product systems (Remmen et al. 2007). Much of the emphasis for LCM relates to the management of information along product chains. For example, tracking and tracing approaches provide both a scientific and management understanding of the sources and origins of materials through supply chains (GHGm 2008; Klassen and Vereecke 2012; Young and Dias 2011). Tracking follows a unit of material downstream, in the direction of life cycle flow (e.g., from mine to smelter to processer and eventually to product end-user). Tracing works in the opposite direction, moving upstream, and seeks to discern the source of a unit of material (e.g., from end-product to manufacturer to components to processer and eventually to original source).

LCM grew from LCA. Both are based in environmental and natural sciences and aim to guide holistic system change at the product level. They tend to emphasize the "what" (energy, materials, emissions, etc.) in the full product life cycle. In contrast, SSCM is based in the social sciences and emerged from management research (Seuring and Muller 2008). SSCM emphasizes management of the "how" (and perhaps the "who") with a focus on the firm and its closest suppliers. As a business management concept, SSCM (Seuring and Muller 2008), also referred as green supply chain management or socially responsible buying (Maignan et al. 2002), tends to focus on a single organization rather than the entire value chain of a commodity or product. In SSCM, a "focal company" like a large brand name manufacturer, which is in a position of influence through its buying power, works to understand its consumption of materials and energy and to manage its immediate supply chain to maximize business

Table 1 Responsible sourcing compared to other approaches to sustainability management of product chains

Approach	Scope	Manages	Methods
Life cycle management (LCM)	Full product chain	Manages resource and energy flows, environmental inputs/outputs, and their impacts.	Mix of concepts, approaches, and natural science tools like life cycle assessment, labeling, design for environment, and material flow analysis *Tends to emphasize the "what."*
Sustainable supply chain management (SSCM)	Company procurement	Manages the firm and its (immediate) suppliers.	Mix of management techniques that address material, information, and capital flows. Including supplier selection, engagement, training, and auditing. *Tends to emphasize the "how."*
Responsible sourcing	Raw material supply	Manages information associated with source (origin) and production of raw materials.	Standards, assurance, certification, and chain-of-custody tools provide assurance of provenance of supply of raw materials. *Tends to emphasize the "where."*

Based on Nilsson-Lindén et al. (2014) and Remmen et al. (2007)

sustainability (Seuring and Muller 2008). Although there is a larger literature on SSCM compared to LCM, relatively little has been considered on how firms manage social issues in full supply chains, and much of that has focused on labor concerns (Yawar and Seuring 2015). Yet, in a global economy, manufacturing product chains and commerce connect suppliers across many tiers, and social issues range from labor conditions in developed countries to more serious human rights and personal security risks in developing nations, like the problem of conflict minerals in the DRC.

Responsible sourcing is presented here as an approach that can be used in LCM or SSCM. Compared to LCM and SSCM, there is surprisingly little research on responsible sourcing per se, although the term has been used in the literature in reference to food and textiles (Loconto and Busch 2010) and building and construction (Glass et al. 2011). Responsible sourcing is an approach that aims to inform and manage aspects associated with the location of production of natural resources (see Table 1). Whereas LCM emphasizes the "what" and SSCM the "how," responsible sourcing emphasizes the "where." Thus, responsible sourcing is a potentially valuable addition to the sustainability toolbox (it is notable that there is still no dominant approach that addresses the "when" of product chains). In this paper, responsible sourcing is seen an approach used as part of LCM activities in which downstream producers seek raw materials and manage upstream production processes to be more sustainable. Downstream buyers seek assurances of origins, sources, or sustainability aspects of purchased materials. Responsible sourcing typically includes information resulting from tracking or tracing of material life cycles (Young and Dias 2012), for example, via certification of origin of material using documentation that maintains an unbroken chain of custody of documentation along the product chain. Responsible sourcing uses specific methods like standards and certification to provide assurances to buyers on the provenance of raw materials and integrity of delivery along the product chain.

2.2 Sustainability standards and certification

There is considerable literature on sustainability standards and certification. Theories and analyses draw on political science (Auld et al. 2008; Cashore 2002), organizational sociology (Busch 2011; Loconto and Busch 2010), law (Abbott and Snidal 2009; Vogel 2008), and management scholarship (Klassen and Vereecke 2012; Linton et al. 2007; Seuring and Muller 2008). Prominent programs provide certification of wood, paper, fish, and fair trade products like coffee and chocolate. The Forest Stewardship Council is acknowledged to be the original commodity sustainability certification program and has been the subject of considerable analysis (Auld et al. 2008; Cashore 2002). These kinds of sustainability initiatives are "nonstate market-driven"(Cashore 2002) forms of private governance (Abbott and Snidal 2009; Vogel 2008). Such programs develop their own private environmental or social standards, rely on (third-party) auditing mechanisms, and leverage market forces to affect voluntary change in upstream commodity production (Loconto and Busch 2010). Downstream producers (often brand name companies) "govern at a distance" (Loconto and Busch 2010) over their supply chains, supported by independent assurances to end-users. An important avenue of research seeks to evaluate whether and how these standards result in sustainability outcomes for communities, workers, and the environment—often in developing countries where primary production occurs (see, for example, the review by the Steering Committee of the State-of-Knowledge Assessment of Standards and Certification (2012)). The ultimate intent is to shift market preferences toward products with superior social, economic, and environmental performance; therefore, certifications are often communicated to final consumers via product labels. Standards developed by private-sector or multi-stakeholder organizations such as companies, industry associations, or nongovernmental organizations are termed "private standards." Unlike international standards developed by the International Organization for Standardization (ISO), they are not government-endorsed, and each program needs to build its own legitimacy. However, the ISO 19011 international standard on auditing of management systems (ISO 2011) is often used as a reference to auditors operating under private schemes.

Sustainability private standards were initially created as multi-stakeholder collaborations between nonprofit organizations and industry to inform and drive consumer behavior, particularly via labeling of agricultural and fiber products. More recently, business-led initiatives have developed that are controlled directly by producers of commodities or driven by buyers seeking assurances about resources used in their branded products or about goods presented in retail shops (Carlsson and Johansson 2013). However, the use of sustainability standards has reached beyond food and textiles to including manufactured products, for example, where brand owners desire traceability information on components or finished goods (Klassen and Vereecke 2012). Thus, interest has developed in responsible sourcing of nonrenewable resources, including metals and minerals.

2.3 Responsible sourcing of minerals and metals

In 2002, the Mining, Minerals and Sustainable Development Project noted that, unlike in forestry and other sectors, there is no mechanism to link final consumers to upstream production of minerals and metals (MMSD Project & International Institute for Environment and Development 2002). Reasons include geographic distance, complexity and long product chains, and the relatively small quantity of metals that is widely distributed and largely not visible in final goods. In the last

decade, the prospects for mineral and metal certification have grown as a number of efforts to connect end-users to sources of minerals and metals are underway or in development for aluminum, steel, gems, petroleum, and other extractives (Young et al. 2014). These sourcing programs aim to serve downstream markets such as construction, transport, jewelry, electronics, and packaging. For example, in the construction industry, responsible sourcing of steel, concrete, and aggregate has developed with government assistance in the UK, where main attributes concern "local" origins and environmental management (Glass et al. 2011).

The product chain for gold has previously received academic attention. One of the first metal-specific efforts was the "No Dirty Gold" activist campaign in 2004 to inform jewelry consumers about the environmental impacts of gold mining (Sarin 2006). The campaign later developed into the multi-stakeholder Initiative for Responsible Mining Assurance (Initiative for Responsible Mining Assurance 2014). Of note too is the Kimberley Process Certification Scheme for diamonds, which is a uniquely governed responsible sourcing initiative that combines industry certification with state import/export regulation (Haufler 2010). Global market access is an important driver for miners upstream who are beginning a practice of "material stewardship," including social and environmental responsibility across material life cycles (Fleury and Davies 2012). Previous research identifies technical barriers in mineral chains (Franken et al. 2012), foreign exchange challenges faced by artisanal and small-scale mining (Hilson 2008), and the lack of transparency in commodity markets (GHGm 2008).

2.4 Conflict mineral problem

The trade of conflict minerals is explicitly implicated in financing and sustaining violence in the DRC (United Nations Security Council 2004). Mining and commerce of minerals (including cassiterite, wolframite, and niobium-tantalite, called "coltan" in the region) and gold feeds armed conflict, widespread violence, and other social problems and risks in the eastern Democratic Republic of the Congo (DRC). Environmental damage in the region is also of concern (Levin et al. 2012). The situation persists largely due to an absence of formal governance (OECD 2011). Civil society groups emphasize the duration of conflict, the millions of deaths in the region, and the ongoing severity of humanitarian conditions (Enough Project 2014b; Global Witness 2014). Concerns such as child labor, sexual violence, and the financing role of mining and mineral trading have been highlighted since the early 1990s (Hayes and Burge 2003; Prendergast and Lezhnev 2009). The conflict mineral problem is propagated by ease of moving minerals from illicit mining into formal channels (Bleischwitz et al. 2012), as is the situation in central Africa where gold and high-value mineral concentrates are smuggled from the DRC into neighboring nations in the Great Lakes Region, then exported to smelters and refineries, and converted into bullion, jewelry, or ubiquitous electronics products for global markets (Koning & Enough Project 2013).

NGO campaigns began to address the conflict mineral problem around 2007. Because 3TG metals find their way into hundreds of thousands of products around the world, activists focused attention on brand name companies in Europe and America that are users of the 3TG metals in their electronic products (Koning & Enough Project 2013) and employed tactics like engaging youth consumers (Young et al. 2010) and using language like "blood minerals"(Enough Project 2014a) that reflect the so-called "blood diamond" concerns (Haufler 2010). Companies responded to the conflict mineral problem because 3TG metals are used in the end-products that they produce, including electronics, automotive, aerospace, and others. Gold is used primarily as bullion and in jewelry, although it is also critical to various industrial and technology applications. In 2007, the electronics industry commissioned its first report on metal sourcing (GHGm 2008), and in 2008 it formed the CFSP, detailed below.

For companies operating in conflict-affected areas or acquiring minerals or metals from such high-risk areas, the *OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas* is the main reference document (OECD 2011). The guide helps companies complete due diligence steps and supports companies throughout the supply chain, including upstream (from mine to smelters and refineries[1]) and downstream (from smelters to end-user). For companies listed on US stock exchanges, there is added pressure from regulation enacted under the Dodd-Frank financial reforms (US Securities and Exchange Commission 2010). The law requires companies that use 3TG in their manufactured products to undertake a "reasonable country of origin inquiry" on the sources of metals and report on 3TG metal use. Similar conflict mineral regulations are considered in Europe, Canada, and other jurisdictions.

Estimates of global 3TG production show that, except for tantalum, the DRC is not a major world producer of tin, tungsten, and gold (at 5, 2, and <1 %, respectively) (EICC & GeSI 2014a; WGC 2012). Nonetheless, the value of illegal mineral trade from the DRC is on the order of hundreds of millions of dollars (Koning & Enough Project 2013) and a substantial source of finance for armed groups. For tantalum in 2008 the DRC accounted for about 30 % of production and illicit

[1] Smelters and refineries are metallurgical facilities that produce crude and refined metal products, respectively. For tin, the product chain includes both smelting and refining; for tantalum and tungsten, these steps are somewhat combined, depending on the final metal or chemical product; for gold, refining is the critical for producing a salable pure product. For simplicity, the term "smelter" is often used to describe both smelting and refining steps.

production was about two thirds of that, estimated to be on the order of $27 million annually (Bleischwitz et al. 2012). With heightened awareness of the conflict mineral problem, production and trade from the Great Lakes Region dropped for a period starting from about 2008, including an embargo on tin exports from 2011 to 2013 (ITRI 2013a). Management of minerals sourced from the DRC is challenged by the complexity of the supply chain, the role of Chinese buyers of minerals, and the weakness of governance in central Africa (Bleischwitz et al. 2012; Hayes and Burge 2003; Prendergast and Lezhnev 2009). As widespread attention to the issue emerged, a number of Western buyers began avoiding all purchases from the region as a simplistic response to remove conflict-associated materials from their supply chains. Further work is needed to accurately estimate quantities of 3TG and the fraction of metal produced that is conflict-associated, preferably including estimates of changes in illicit production over the last decade.

3 Theoretical framework

The "tripartite standard regime" refers to the structure of standards, certification, and accreditations that describes private standards (Busch 2011; Loconto and Busch 2010). In the present research, this theoretical framework (Fig. 1) is employed to characterize the structure of responsible sourcing programs on three dimensions. The first dimension considered is "governance" which considers the roles of firms, civil society, and government in initiatives (Abbott and Snidal 2009) and includes ideas of authority, trust, and legitimacy. Without government authority, a private program needs to earn these values. Thus, governance broadly considers the ownership and management aspects of a program: how members are recruited, how decisions are made, accreditation of auditors, ownership of intellectual property, engagement with stakeholders, and communication of program activities and program performance. The second dimension is "standards," which describes the sustainability criteria and substantial requirements that are set by programs and expected for compliance. Appropriate requirements and criteria are developed to achieve effective sustainability performance outcomes. The third dimension of the tripartite standard regime framework refers to accreditation, which here is more broadly considered as "certification" (see Fig. 1) and includes audit processes and procedures like audit timelines, audit sampling, communication of audit findings, and appeal mechanisms. Certification processes, rules, and procedures guide the auditee, the auditor, and the program authority. Audit processes and certification procedures provide efficiency to certification.

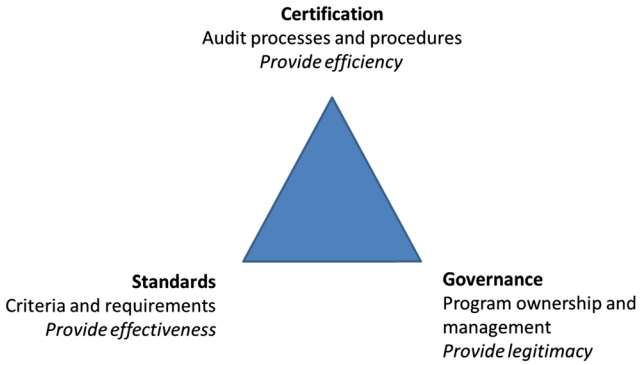

Fig. 1 Research framework for program analysis. Adapted from the tripartite standard regime (Busch 2011; Loconto and Busch 2010)

4 Methodology and data

An abductive approach allows for the research to move iteratively from practice to theoretical interpretation, in order to discover relevant structures and mechanisms (Bryman et al. 2011). The present research uses a qualitative research strategy, employing a comparative design looking at multiple cases to contrast findings and probe theoretical explanation. More specifically, guided grounded theory method was applied to structure the enquiry (Glaser and Straus 1967). This allows for open observation, enabling comparison across cases and providing avenues for new concepts. The tripartite standard regime (see Fig. 1) was used as the preexisting theoretical framework to guide the enquiry on responsible sourcing programs. Empirical data are progressively analyzed and compared to this framework, which was iteratively adjusted based on new evidence and theoretical understanding.

Two layers of research are performed. First, 16 conflict-free programs that include coverage of 3TG metals are analyzed. Program structures and mechanism are progressively categorized and sorted using the tripartite standard regime framework, under the headings of governance, standards, and certification, and subcategories are developed based on distinctions and similarities (Table 2). Data sources include public documents and websites, third-party reports, and information on programs and member organizations. Typically, program criteria are provided in standards and protocols, certification is described in procedures and guidelines, and program performance is often provided as performance metrics, like the numbers and types of compliant organizations. Copies of certificates of compliance are accessible for some programs. Findings are checked against empirical data obtained though interactions with program participants, mostly relating to the CFSP, at the second layer of research.

In the second layer, the mechanism of conflict-free certification was explored more deeply with empirical evidence acquired in 2012–2015 through direct active participation in and observation of the CFSP. The CFSP program is the largest and most comprehensive of the conflict mineral sourcing

Table 2 Certification programs for conflict minerals and conflict-free sourcing of 3TG metals

Program name	Governance		Standard			Certification		Reference
	Program owner and history	Coordination with CFSP	Metals covered	Attributes	Product chain stages covered	What is audited	How assurance is communicated	
Conflict-Free Smelter Program (CFSP)	Downstream industry—electronics and brand name manufacturers (Conflict-Free Sourcing Initiative). First certification 2010.	CFSP is the central, global, multi-metal program.	Au, Sn, Ta, W	Conflict-free	Upstream—mine to smelter/refiner	Companies at smelter and refinery facilities	Listed on website after audit	EICC & GeSI (2014a)
ITRI Tin Supply Chain Initiative (iTSCI)	Upstream industry—mines, transport, smelters in the Africa Great Lakes Region	YES—CFSP uses iTSCI	Sn, Ta	Conflict-free	Upstream—mine to smelter/refiner	Companies handling bags of tagged minerals	Listed on website after audit	ITRI (2014)
Tungsten Industry - Conflict Minerals Council (TI-CMC)	Established 2013 by smelters, refineries, and producers of tungsten metals and products.	YES—strong coordination for tungsten	W	Conflict-free	Upstream—mine to smelter/refiner	None	Letter of commitment	TI-CMC (2014)
London Bullion Market Association (LBMA) Responsible Gold Guidance	Downstream industry—refiners. Established 2012 as part of the general London Bullion Market Association (LBMA) Good Delivery List standard	YES—cross-recognition	Au	Conflict-free, anti-terrorism, money-laundering, and other attributes	Upstream—mine to refiner	Refinery firms	Company certificate	LBMA (2013)
World Gold Council (WGC) (2014) Conflict-Free Gold Standard	Upstream producers—WGC association of large mining companies. Established 2012.		Au	Conflict-free	Upstream—miners	Mining firms		WGC (2012)
Dubai Multi Commodities Centre (DMCC) Practical Guidance for Responsible Sourcing	Downstream market operator DMCC. Established 2013 as part of the DMCC Dubai Good Delivery standard		Au	(unknown)	Upstream	Refinery firms	(Unknown)	DMCC (2014)
Certified Trading Chains Initiative (CTC)	Government—German Geological Service (BGR)		Au, Sn, Ta, W	Geological origin of mineral	Upstream—mine sites	Mineral samples	Government database	BGR (2014); Franken et al. (2012)
Conflict-Free Tin Initiative	Multi-stakeholder—industry, NGO, government.	YES—uses CFSP	Sn	Conflict-free	Upstream	Companies in a "closed pipeline"		Resolve (2014a)
Solutions for Hope Project	Multi-stakeholder—industry, NGO, government.	YES—uses CFSP	Ta	Conflict-free	Upstream	Companies in a "closed pipeline"		Resolve (2014b)
Conflict-Free Gold	Multi-stakeholder operated by Partnership Africa Canada	YES	Au	Conflict-free	Upstream	Closed pipeline		Partnership Africa Canada (2014)

Table 2 (continued)

Program name	Governance		Standard			Certification		Reference
	Program owner and history	Coordination with CFSP	Metals covered	Attributes	Product chain stages covered	What is audited	How assurance is communicated	
Conflict Minerals Reporting Template (CMRT)	Downstream industry – Conflict-Free Sourcing Initiative, EICC, GeSI. Electronics and brand name manufacturers	YES, same owner	Au, Sn, Ta, W	Source of material	Downstream—smelter to OEM	None	Individual firms	EICC & GeSI (2014b)
Signet Responsible Sourcing Protocol[a]	Private company, Signet Jewelers Limited, standard for suppliers of gold for jewelry		Au	Multiple responsibility criteria	Downstream	Not clear	Company declaration	Signet Jewelers (2013)
SCS Certified Responsible Source	Private second-party ecolabel by SCS Global Service for refiners and manufacturers to serve fabricators, jewelers, and retailers		Au and gemstones	Multiple responsibility criteria	Downstream	Not clear	Auditor certificate	SCS (2014)
Fairtrade and Fairmined Gold	Multi-stakeholder, Fairtrade International, FLO-CERT, Alliance for Responsible Mining (ARM). Artisanal and ethical sourcing of gold		Au	Multiple sustainability criteria	Full supply chain	Metal producers and product chain	Product certificate	Alliance for Responsible Mining (2014); Hilson (2008)
Partnership for Social and Economic Sustainability	Private company, closed pipeline by KEMET Inc., manufacturer of components. Announced 2011	Uses CFSP	Ta	Conflict-free and source of material	Full supply chain	Companies in a "closed pipeline"	Company declaration	KEMET (2014)
Chain-of-Custody (CoC) Certification, Responsible Jewellery Council (RJC)	Upstream and downstream industries—miners, jewellery manufacturers, and retailers. First certification 2012	YES—cross-recognition	Au, Pt, Pd, Rh	Multiple responsibility criteria	Full supply chain	Facilities in product chain	Company certificate	Responsible Jewellery Council (2014)

[a] This is typical, as similar private programs are operated by other jewellery companies

initiatives: in addition to members from over 200 downstream manufacturers that rely on 3TG metals in their products, the CFSP directly connects to most of the other 15 programs, either using information from these other programs, providing compliance results to other programs, or through cross-recognizing compliance with other programs (as identified in Table 2). The researcher's participation was as a member of the audit review committee of the CFSP for 3 years, which included more weekly meetings, correspondence with other committees, members, and program managers, reviews of confidential audit documents, and detailed conversations with third-party auditors and auditee companies. This access provided qualitative and quantitative data on approaches and efforts, including detailed information on noncompliances to program protocols at smelters and refineries and corrective actions taken. Evidence accessed included audit reports, company policies, and management records on more than 140 metallurgical facilities around the world, including confidential details on smelter purchasing practices, training procedures, supplier visits, and management systems. Additionally, monthly telephone calls with NGO observers and other stakeholders provided context on broader industry and policy developments.

5 Program review

Results of the program analysis are summarized in Table 2 according to the research framework. Programs address different stages in the product chain, cover different metals, and may be regional or global in coverage. The first program listed is the CFSP, which is the largest and most comprehensive of the conflict-free sourcing schemes and the only auditing program operating across all 3TG metals. The role of other conflict mineral programs is often significant. Eleven of the 16 programs focus on gold, including two programs that provide conflict-free certifications to gold refiners (London Bullion Market Association (LBMA) and Responsible Jewellery Council (RJC)). The other metals are more narrowly represented, as is logical given the relative size of these industries. Two of the programs include government members, and four include NGO members within multi-stakeholder initiatives; membership in nine of the programs is exclusive to industry. Schemes that focus on the upstream 3TG product chain are grouped first in Table 2; several of these are collaborative efforts between companies, for example, among tungsten producers (Tungsten Industry—Conflict Minerals Council (TI-CMC)) and gold mining companies (WGC). The iTSCI program is notable in that it operates locally in the Great Lakes Region of Africa to support sourcing of tin, tantalum, and tungsten. Most conflict mineral programs are still adding additional features as they evolve over time. For example, in a fully evolved certification program, auditors function autonomously, undertake audits, and provide certification without interference or review from the standard setting body. A key aspect of the tripartite standard regime is accreditation of auditors; however, the CFSP does not yet provide auditor accreditation, although the RJC gold program does.

Programs that operate in the downstream product chain are listed later in Table 2. The CFSP initiative provides an additional data collection tool (Conflict Minerals Reporting Template (CRMT)) to help manufacturers identify smelters and establish whether metals in their products originate from conflict-free sources (Fig. 2). In contrast to the more collaborative upstream activities, several jewelry and electronics firms have created independent branded programs at the downstream end of the product chain, even if they use some of the same upstream standards and assurance systems. The world's largest manufacture user of tantalum, for example, operates its own "closed-pipeline" supply chain using CFSP compliant smelters to feed its manufacturing of tantalum capacitors (KEMET 2014). The presence of a number of closed-pipeline schemes is novel in itself. These are programs that enable a full life cycle chain of custody of segregated material along the product chain, from certified conflict-free mines in the DRC, all the way to final end-product in the USA or other markets. That the material originates from the DRC is significant, as it allows for that country to participate in trade and benefit economically. Several closed pipeline efforts are multi-stakeholder projects supported by government, NGOs, and private companies in the product chain linking mines, smelters, chemical makers, component, and end-product manufacturers (see Table 2).

6 Conflict-free sourcing program

The CFSP is the largest of the conflict mineral programs. Created in 2008 by two electronics industry associations, the Electronic Industry Citizenship Coalition (EICC) and the Global e-Sustainability Initiative (GeSI), the CFSP has operated since 2012 as a program of the Conflict-Free Sourcing Initiative supported by industry associations. Two groups of companies are involved: members and smelters. Member companies pay to access to details on CFSP compliant smelter companies. In this way the scheme helps member firms satisfy the US regulation on corporate disclosure of use of conflict minerals, including reasonable country of origin inquiry (US Securities and Exchange Commission 2010) of 3TG metals. Most of the 130 member companies are electronics firms, although the initiative also includes members in aerospace, automotive, general industry, and machinery, plus a small representation of upstream metal producers. As an entity, the initiative includes working groups and committees, full-time staff, consultants, and company experts. It is structured with a number of committees tasked with smelter identification, protocol development, auditor development, audit review, policy analysis for due diligence responses to OECD and US regulation, education, and stakeholder outreach. Civil society stakeholders are informed and consulted regularly but are not directly involved in program decisions. Two independent experts sit on the audit review committee that oversees compliance decisions. Details on the CFSP are available at www.conflictfreesourcing.org.

CFSP uses several protocols for the 3TG metals, which require compliance in two areas. First, the smelter company must have in place a management system that includes a conflict-free mineral policy, procedures, and practices to screen mineral and metal purchases and a training program for employees. Second, the smelter company needs to maintain records on each lot of metal feedstock purchased. Documentation must be sufficient to demonstrate traceability of the purchase to a source and/or origin not associated with conflict in the DRC. Low-risk sources, including materials reasonably identifiable as recycled, by-products from production of other metals, and historical sources such as old stockpiles, are deemed conflict-free. Materials sourced directly or indirectly from mines require documentation to demonstrate

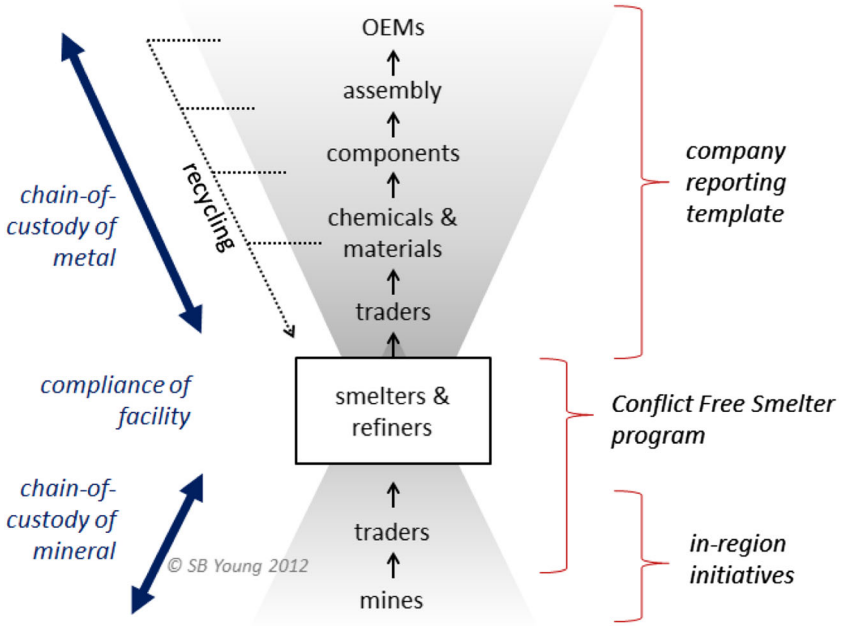

Fig. 2 Product chain of 3TG metals to electronics (from Young and Dias 2012). Metallurgical smelters and refiners are targeted by the Conflict-Free Sourcing Program as a chokepoint for responsible sourcing of minerals and life cycle management of metals

country of origin. Transportation bills, export/import records, and mine licenses are typically used as evidence of the origin of mineral concentrates shipped from mines to smelters. As the risk of sourcing from conflict regions increases, the rigor and detail of documentation requirements increase.

Under the CFSP audit procedures, most audits are performed annually. Individual transactions are sampled to test reasonableness of being conflict-free. It is necessary for firms to maintain documents with appropriate controls as part of their management systems. Auditors perform visual inspections of materials in inventory and calculate a mass balance to ensure that sales for the audit period correspond to purchases, adjusted for inventory changes. Teams, typically of two auditors, require 2 days to visit large facilities when auditee companies are appropriately prepared. Auditees often do not meet all CFSP protocol requirements on their initial audit and, after review by the CFSP audit committee, may be provided 90 days to perform corrective actions. Re-audits may also be required. Deficiencies may include simple management system gaps, like failing to publicize their conflict mineral policy, or may be more serious noncompliances, such as insufficient documentation on country of origin for a shipment received. The majority of auditees are able to fix noncompliances and are listed as compliant with requirements that they explicitly avoid "minerals that directly or indirectly finance or benefit armed groups from conflict-affected regions" (EICC & GeSI 2012). Few smelters actually source from zones in the region. This is done despite the need for significant paperwork and on-the-ground visits to mines to confirm conflict-free status.

CFSP compliance varies for each 3TG industry since audits began in 2008, although it is clear that a significant fraction of 3TG smelters and refineries is engaged in the CFSP and has successfully achieved compliance (Fig. 3). In its first 3 years, the CFSP oversaw slightly more than 100 audits in over 20 countries, with more than 60 achieving compliance. Almost one third of identified 3TG companies were compliant as of early 2014. It is important to note that many of the smelters and refineries listed as conflict-free have achieved their compliance because they are not sourcing from the DRC or neighboring countries.

Global coverage of the CFSP includes tin producers in Indonesia, China, and Bolivia; tantalum facilities in Brazil, Germany, and India; tungsten processors in the USA, Austria, and Vietnam; and gold refineries in more than 20 countries, including large firms in Switzerland and Japan. The total number of identified companies gradually increased, as new actors in each 3TG industry continue to be discovered as the program probed deeper into the metal industry, particularly in China. The CFSP identified a total of 209 companies producing 3TG at the beginning of 2014. Thus, 32 % of smelter and refinery companies were compliant and an additional 13 % were active in the program; this amounts to a total of 45 % of smelter and refinery companies in the 3TG sectors voluntarily engaged in the CFSP. The corresponding quantities of metals produced by these firms are proportionally much higher, as the compliant population represents most of the largest global producers;

Fig. 3 Progress in conflict-free compliant smelter and refinery facilities (2008 to April 2015) (source: www.conflictfreesourcing.org)

however, exact quantities are not calculated. This is a point for further research.

7 Progress in responsible sourcing of 3TG metals

7.1 Tin

Tin producers, including large and small smelter companies, took an early interest in the CFSP, although it was a couple of years, after changes in program standards, before compliant firms were listed. At the end of 2014, 40 % of known tin producers were participating in the CFSP (see Fig. 3), including metal refineries in over ten countries. The international tin industry association (ITRI) is the body that facilitates conflict-free activities in the global tin industry, from the mining of cassiterite ores to the refined grade metal wires and ingots. The tin industry manages an in-region program, the ITRI Tin Supply Chain Initiative (iTSCI), which supports about 130 members, most of whom operate in the DRC or source from the region. The program aims to meet OECD guidelines for due diligence, including risk assessment at mine sites in the DRC, and operates a conflict-free "bag-and-tag" scheme, which plays a significant role in the product chain for some tin smelters that achieve CFSP compliance. This chain-of-custody mechanism provides product segregation of minerals from mines in the DRC and neighboring regions, including transportation and export, to tin smelters overseas, for example, to the Malaysia Smelting Corporation, which is a large buyer of African tin minerals (ITRI 2013b).

7.2 Tantalum

Tantalum companies were the first to become compliant to the CFSP protocol soon after the program commenced operation in late 2010. Engagement began with producers in the USA; however, by 2012, most producers worldwide were active, and by 2014, almost all of the identified tantalum smelter companies were compliant, 56 of the 58 known tantalum smelters (see Fig. 3), leaving only two small facilities remaining. One latecomer is a large producer previously suspended from the tantalum industry association after being implicated in the purchase of conflict-associated materials (Sparks 2013). Management of tantalum supply chains includes several additional programs. Tantalum ores are included in the iTSCI bag-and-tag scheme for production from DRC. The German BGR operates a unique "fingerprinting" research effort that traces precise geographic origins of shipped mineral concentrates, using laboratory methods and a regional database of chemical and mineralogical properties (Franken et al. 2012); however, this method is costly and limited to the examination of minerals before they are converted into metals in the smelter.

Conflict-free sourcing of tantalum has reached an advanced scope and scale. By 2014, the large majority of facilities were compliant, covering 12 countries including a significant number of producers in China. Responsible sourcing touches in the order of 95 % of global production of

tantalum (although this precise quantification is the subject of future research). Several observations arise. First, it should be highlighted that efforts started in 2008 by electronics companies for LCM of their own products now benefit all users of tantalum metal, across multiple industries, globally along the full product chain. Second, the tantalum industry is moving to a point when the entire economic stock of this metal will be produced conflict-free. If 100 % conflict tantalum sourcing occurs, the need for supplier-by-supplier "chain" management of this issue will no longer exist: comprehensive responsible sourcing will collectively serve all users.

7.3 Tungsten

With only about 50 smelters worldwide, the tungsten industry is the last of the 3TG sectors to participate in the CFSP. One reason for the delay in this sector is that less than 3 % of global tungsten is mined in the DRC, with the bulk of mineral originating and processed in China. Under a 2013 agreement between the CFSP and the TI-CMC, the first tungsten company achieved compliance in 2014 (see Fig. 3). Under the terms of the TI-CMC agreement, the highly confidential nature of industry transactions is preserved, while allowing auditors to confirm compliance of management systems and tungsten sources. In 2015, approximately half of the upstream producer companies were listed as actively engaged or progressing toward CFSP validation.

7.4 Gold

Gold is the largest of the 3TG industries and already has the largest number of conflict-free compliant facilities (almost 100 from 2012 to 2015), including involvement via several industry programs (CFSP, RJC, and LBMA). About a hundred active refineries worldwide are members of at least one of ten gold associations or gold exchanges. Of these, the LBMA is the dominant group that oversees a list of 63 refineries whose gold bars are accredited for "good delivery" of physical gold (i.e., bullion product like gold bars, as opposed to financial product). The designation includes assurances of metal purity, refining standards, and trading practices. Since 2012, Good Delivery Gold Refiners have also been required to comply with the LBMA Responsible Gold Guidance, which includes anti-money laundering principles and conflict-free criteria based on the OECD guidance and is included in regular third-party refinery audits. Consequently, the gold sector has the greatest number of companies compliant to the CFSP, about 80 of the 150 firms identified (see Fig. 3). It is also, by far, the largest of the four 3TG industries financially. Many of the companies on the CFSP list achieve compliance through the LBMA audit program, others participate directly in the CFSP, and about 10 % engage through the RJC chain-of-custody mechanism. The Dubai Multi Commodities Centre provides its own responsible sourcing guidance, and more conflict-free gold mechanisms may develop, as other gold market associations, such as the Tokyo Commodity Exchange and Shanghai Gold Exchange, provide accreditations.

The gold industry is unique in many ways. Gold functions as a financial instrument in addition to being a raw material; pricing is, therefore, set on a global financial exchange, far removed from the demands of industrial users, who account for about 10 % of consumption. Some metallurgical facilities rely only on primary mined feedstocks, some resort exclusively to recycled inputs, and others use a mix of sources. Unlike the other metals discussed here, gold can be easily processed to tradable metal form; therefore, the industry has a larger number of very small refiners that circumvent the major gold associations. Artisanal and small-scale gold miners are supported by several multi-stakeholder initiatives that focus on conflict-free attributes as well as environmental, social, and economic criteria. These schemes emphasize principles like labor rights, employment equity, and distribution of income. They include efforts in the DRC (Partnership Africa Canada 2014), the Fair Trade and Fair Mined gold standard from the Fair Trade Labelling Organisation, and the Alliance for Responsible Mining (ARM) (Alliance for Responsible Mining 2014; Hilson 2008), which certifies mining cooperatives in Bolivia, Columbia and Peru (FLO-CERT 2014).

Several factors suggest that the situation for responsible sourcing of gold is more complicated than for the other 3TG metals. In the global market, DRC sourcing is relatively small, and the majority of gold goes into investment products like bullion and jewelry, not into manufactured goods; therefore, the driving forces exerted by manufacturers concerned about the US regulation or about social issues in the DRC are diluted. Organizationally (see Table 2), there are multiple organizations administering conflict-free gold programs, and even though they may collaborate, these initiatives present competing management requirements and some include very different expectations, like anti-terrorism criteria, that diffuse the focus on conflict minerals. In terms of industry structure, there are a great number of small producers who are geographically distributed, and a significant fraction of gold is sourced from recycled sources, like old jewelry. This means that the chokepoint for gold is far less distinct than for the other 3TG metals. Compounding the situation, gold is infamously easily smuggled or traded anonymously in forms like small bars or crude jewelry, which are both dense and valuable. This inhibits material traceability and challenges auditors who need to examine chain-of-custody documentation. In summation, the gold product chain is less controlled and "leakier" in operation compared to the other 3TG. For conflict-free sourcing, it is

anticipated that large refiners and those associated with prominent associations will gradually achieve compliance; however, greater than 20 % of the industry may not be so motivated.

7.5 Mitigating the conflict mineral problem

For the conflict mineral problem, the most important question related to this research is whether certification programs have improved social conditions and reduced conflict in the DRC. The causality of program effectiveness is beyond the scope of the present study—and performance outcomes, in general are difficult to assess (Steering Committee of the State-of-Knowledge Assessment of Standards and Certification (2012)—but several reports indicate that there have been impacts in regions where responsible sourcing programs are active. The tin industry asserts that its own iTSCI program has contributed to social development in the DRC (ITRI 2013b). One NGO reports that revenue flowing to armed groups from sales of tin, tungsten, and tantalum reduced since 2008; however, it also observes that illicit and smuggled gold is now the dominant source of conflict mineral revenue (Koning & Enough Project 2013). An analysis and review of multiple reports, which considers a mix of factors and outcomes in the region, suggests that there is evidence of social change in both positive and negative directions (Manhart and Schleicher 2013). Of additional concern is the risk of economic boycott of the region, which has been the case with several tungsten producers.

More visible than social outcomes, evidence suggests that conflict-free sourcing impacted 3TG markets. There is a buyer preference in the supply chain for conflict-free versus noncompliant suppliers; ad hoc evidence suggests that this is reflected in pricing of tin, tantalum, and tungsten (but not gold, as discussed above). Export prices of raw minerals from the Great Lakes Region of Africa are as much as 70 % higher for compliant versus noncompliant mineral lots (Enough Project 2012). Moreover, smelters and refinery companies have responded to market demand: for example, tantalum and tin companies that were initially disinterested in the CFSP subsequently approached the initiative and requested audit program participation, citing compliance as necessary to sell their products.

8 Analysis of structure and operation of responsible sourcing of metals

Several strengths and weaknesses of responsible sourcing emerge from the analysis of programs and conflict-free sourcing mechanisms.

8.1 Downstream manufacturers are using market forces to pull for changes in practices at producer companies that are multiple tiers upstream in the product chain

The metaphor of the "chain" is appropriate given that physical chains can be pulled—but not pushed. From the program analysis, it appears that in markets where downstream companies are more actively "pulling" on the product chain, they have greater influence on practices in upstream companies. This is consist with literature on sustainability standards, which suggests that successful commodity certification programs rely on market demand leading market supply (Conroy 2007). Compared to other commodity initiatives, particularly in food and agriculture, which tend to be consumer-oriented, or where downstream companies are less influential and market forces are more diffuse, the responsible sourcing of conflict-free metals has advanced rapidly. In less than 4 years of operation, one third of smelter and refinery companies are compliant, including very substantial results for tantalum. By comparison, in its first 15 years, the Forest Stewardship Council certified on the order of 12 % of working forests (Conroy 2007), and in 4 years, the Roundtable on Sustainable Palm Oil certified 14 % of global crude palm oil production (RSPO 2014).

End-user companies in the downstream of product chains create market demand through purchasing conflict-free materials. These firms are motivated by regulatory requirements—and in many cases—by stakeholders and corporate reputation. It appears that markets, not government regulation, are the dominant governance mechanism relevant to conflict-free supply, particularly when 3TG metals are traced upstream. The US law directly impacts US-based companies and many multinational corporations but has little direct impact on smelters and refineries, as only 10–15 % of 3TG producers are located or publicly traded in the USA. The forces acting on upstream smelters and refineries could be several: pricing, competition, customer risk, corporate policy, or social responsibility. Mechanisms involved in the market pull of conflict mineral product chains should be explored in future research.

8.2 Collaboration among companies and programs has enabled engagement with producers and increased scale of compliance

Collaborations appear with many of the programs examined, for example, those that bring together downstream industries like electronics or jewelry producers (see Table 2). In some areas, there are strong cross-sector alliances between government, NGO, and industry sectors; these often deal directly with complex circumstances in the DRC. Other collaborations are more industry-based, for example, amongst company peers in downstream manufacturing (e.g., CFSP, RJC) or among upstream producers (e.g., LBMA, TI-CMC).

Collaboration exists also across different programs. The CFSP has established agreements with other conflict-free programs that run in parallel (see Table 2), including coordination with the TI-CMC and cross-recognition of audits on gold refiners participating in the LBMA Responsible Gold Guidance and the Chain-of-Custody Certification program run by the RJC. These agreements increase the scope of coverage of compliant companies, strengthen awareness and interaction with smelters, and provide efficiencies in auditing processes. The results in Fig. 3 are aggregated from multiple programs.

There is also interesting collaboration along product chains. For example, from confirmed conflict-free mines to smelters, the iTSCI program provides due-diligence services to support traceability of tin, tantalum, and tungsten; and from smelters to end-products, the CRMT tool assists manufacturers to trace 3TG metals into their supply chains back to CFSP compliant producers. Manufacturers who are members of the CFSP share data on their upstream 3TG suppliers without exposing sensitive commercial information on immediate component suppliers. They also coordinate efforts through the initiative to connect with metal producers. This includes site visits to engage small company smelters, technical training at sites not familiar with auditing and standard expectations, and even financial support that is available to help pay the costs of the first audit of a smelter. Thus, brand name product manufacturers based in developing countries reach across complex long product chains to distant producers in Indonesia, South America, and China.

8.3 Managing at chokepoint in the product chain supports efficient responsible sourcing

Development of standards for managing sustainability of metal supply chains poses a number of inherent challenges. Early efforts by electronic manufacturers to trace their purchases of metals proved difficult: complex product chains can easily involve five to nine facilities in different locations from mine to end-product. The sheer number of small producers is unmanageable: in the DRC alone, there are an estimated 10,000 artisanal and small pit 3TG mines (Resolve 2010). This is further complicated by the nature of commodity markets, which, by definition, support fungibility and hence inhibit transparency of information on trade paths and metal flows (Young and Dias 2012). Moreover, in the metallurgical industry, minerals are often supplied from a mix of different global sources, and subsequent conversion of minerals into metal at smelters involves significant chemical and physical transformations, which effectively prevents traceability of metal units (Young and Dias 2012). Interestingly, this challenge also presents a strength that was realized in the design of the CFSP. Because of the sophistication and capital required to build smelters and refineries, there are a limited number of these facilities. There could be as many as 500 companies worldwide producing 3TG metals; however, only 200–300 are suppliers of materials that go into electronic, automotive, industrial equipment, machinery, aerospace, consumer, and other products manufactured by CFSP members. Thus, the CFSP targets smelters and refineries as a chokepoint for control of 3TG metals in the product cycle (Fig. 2). From 2008 to 2015, the initiative identified over 400 smelters and refineries, listed in the public CMRT tool. Almost all 3TG metal flows pass through these sites. Consequently, instead of dealing with 1000s of mines or 10,000s of component manufacturers, the primary point of intervention for control of metal supply is limited to several hundred discrete facilities, where purchased inputs of minerals and metals can be expressly managed and auditors visit to assure practices.

8.4 Management system standards support auditable business processes at supplier facilities

A key strength of the conflict mineral programs is the emphasis on management systems. The CFSP and most other programs do not certify materials: rather, they provide third-party assurances that metal smelter companies are sourcing conflict-free raw materials. Over the first years of the CFSP, the protocols were revised to shift emphasis away from detailed and specific reviews of material transactions toward emphasis on effective and integrated management systems. The model is similar to ISO 14001 environmental and ISO 9000 quality management systems, which use policy and management processes to drive continual improvement of company systems and which are designed to be third-party audited using the ISO 19011 guidelines. Third-party auditors visit smelters and refineries to check policies and procedures in management systems. Purchases of minerals and metal feedstocks are audited for documentation as a check on effectiveness of the sourcing management system. Depending on the 3TG facility, a company can have tens, hundreds, or even thousands of lots of mineral purchases per year. By managing suppliers at the company level (or more specifically at the facility level) rather than at the product level, conflict-free programs have the ability to cover significant volumes of metal production with relatively few compliance audits. However, one weakness of this approach is inherent in examining historical records: past performance is not necessarily indicative of future results, and if management systems and procedures breakdown, any ongoing supply of materials is not assured. Buyers and other stakeholders need to be clear that, unlike programs typical of food or textile consumer products, it is not goods that are certified under this approach; rather, it is the producers of 3TG metals that are compliant.

Conflict-free sourcing initiatives benefit from other business process efficiencies. The whole arena is relatively new and therefore started without preexisting practices, rules, or expectations; therefore, standards were designed afresh

without constraints. Most programs are narrowly designed to address criteria concerning conflict in the Great Lakes Region of Africa, although some mix in other aspects like anti-terrorism or environmental practices (see Table 2). Lastly, initiatives have the benefit of highly engaged and competent upstream businesses and industry associations. The electronics industry, in particular, has familiarity with management systems, standards, and auditing schemes and has prior collaboration experience.

9 Discussion

A number of observations arise that contribute to scholarship of LCM, SSCM, and sustainability standards and certification.

Conflict-free sourcing initiatives require smelters to implement what might be termed "responsibility management systems." The underlying premise is that responsible products are the result of responsible organizations with integrated policies and effective business processes. This supports scalability and reach of responsible sourcing, as relatively few companies need to be audited to cover large production volumes. Management systems are applicable to all types of business, of any size, in any region or industry, and management systems can be easily expanded to consider additional attributes, for example if social policies need to be augmented with environmental aspects. This describes an approach that is more in alignment with SSCM than with LCM approaches, given the focus on organizational management.

Nonetheless, responsible sourcing fits the definition of LCM as described by UNEP/SETAC: it is product-focused active management that targets upstream production activities and organizes and analyses product-related information (Remmen et al. 2007). Manufacturers of electronics, jewelry, and other goods are doing LCM to incorporate conflict-free attributes into their products, actively managing social attributes of raw materials over the whole life cycle, from mining to end-products. Collaboration along product chains is identified in the literature as desirable for LCM (Balkau and Sonnemann 2010). Initiatives like the CFSP capture product information on raw materials and coordinate collaborative efforts for continual improvement of raw material suppliers. In closed pipeline programs, the entire material chain is managed to ensure traceability. By working together in programs, individual manufacturing firms avoid the need to maintain independent compliance programs and are able to share costs and effort, which increases effectiveness while reducing the number of requests made to suppliers.

Several of the conflict mineral programs are structured according to the norms of sustainability standards and meet the criteria of "nonstate market-driven governance" (Cashore 2002): programs rely on the market to connect and regulate sellers and buyers along the product chain, government is not directly involved, broader stakeholders including NGO groups grant authority to the initiative, and third-party auditors are used to enforce compliance. The CFSP followed the basic development observed for certification programs, beginning with standard setting, followed by early participation by leading companies, and then a wider group of companies in the supply chain becoming engaged, seeing the initiative as necessary (Conroy 2007). Through this mechanism, one industry drives change in another industry. This contrasts to multi-stakeholder initiatives that are driven by NGO objectives and seek to provide sustainable products to consumers, and to business-led initiatives which shape change within their own industries. Companies in electronics and other manufacturing cooperate through responsible sourcing programs to "govern at a distance" (Loconto and Busch 2010) and influence social issues in far off activities of mining and metal companies.

9.1 Observations for SSCM

A scholarly review of social issues in SSCM identifies communication, compliance, and supplier development strategies used by buyers to manage suppliers (Yawar and Seuring 2015). All three of these strategies are apparent in efforts addressing the conflict mineral problem, and several observations arise from the present research that contribute to understanding SSCM and social issues.

First, the use of chokepoints to manage product chains appears novel. They work as an efficient means to identify and engage with suppliers who are multiple tiers into manufacturing product chains, quite removed from end-product manufacturing (see Fig. 2). Nonetheless, these targeted companies can be influenced to develop more sustainable systems and practices. Smelters for the four 3TG metals are located in more than 25 countries, including many in the Global South, and vary in size and ownership, from small family-owned tin smelters (with fewer than 20 employees) to multinational corporations. Characterizing the types of supplier firms, their management, and how these factors relate to program participation and compliance are areas for future research.

The chokepoint concept also relates to the position of "focal companies," which drive activities of their suppliers. In the conventional sense, end-product manufacturers of electronics and other goods are the focal companies in 3TG product chains. In the CFSP specifically, there are more than 100 firms in seven major end-use industries that buy 3TG metals. It is proposed, however, that there may be multiple focal companies in any one product chain: smelters that undertake responsible sourcing management systems are, in effect, acting as focal companies for the management of their raw materials. Each compliant smelter engages with its suppliers, employing SSCM strategies, to ensure that mineral suppliers follow

expectations for conflict-free sourcing (refer to Fig. 2). Thus, there is an embeddedness occurring in SSCM: manufacturers are end-product focal companies, and metal producers are raw material focal companies. This is further complicated because of the nonlinear character of supply chains. It is more accurate to conceive of intersecting networks of material flows that deliver metals from mines to producers to fabricators to manufacturers to final end-products.

Collaborative sourcing programs allow individual firms to leverage resources and scope of SSCM strategies. For example, in support of the CFSP, there is coordination and distribution of supplier development among multinational companies, many of which individually provide leadership, expertise, and resources to the CFSP. Suppliers are contacted, engaged, and validated for the CFSP via facility visits from company representatives. Focal firms directly engaged with upstream metal suppliers, providing education, technical training, and management compliance advice. The management system is also a form of supplier development, as it requires suppliers to have strong procedures and business processes in areas including purchasing and information management, which may enhance general management capacity. One novel strategy observed in the present study is financial assistance from a pooled fund, provided to suppliers to assist in audit costs. These strategies for communication, compliance, and development of suppliers present avenues for future research on SSCM.

9.2 Generalizability of responsible sourcing of raw materials

The area of conflict mineral management presents a model that may be useful more generally, particularly given the emergence of organizations and programs to provide assurances on sustainability of minerals and metals (Young et al. 2014). This includes growing interest in stewardship and certification programs for major metals such as aluminum (Aluminium Stewardship Initiative 2014) and steel (Benn et al. 2014; Steel Stewardship Forum 2014), and comprehensive certification of mining (Initiative for Responsible Mining Assurance 2014). For metal production, the idea of the chokepoint is widely applicable. For example, aluminum smelters are a potential chokepoint controlled by a relatively small number of companies, as are blast and electric furnaces for steel production. Chokepoints for other commodities may include wood mills, biofuel refineries, cotton gins, and fishery landings. However, in some ways, the conflict mineral response is not transferable. The problem in the DRC is unparalleled in human severity and not disputed in science, thus motivating response from a multitude of actors. The relatively narrow focus of conflict-free standards is not typical of broader sustainability programs that use long lists of environmental, social, and economic criteria—which complicate processes of standard setting and auditing. Moreover, various schemes (and their member companies) are not really competing against each other on the social issue: each is motivated, whether altruistically, by regulation or by market forces, toward a common goal to human conflict.

9.3 Considerations for LCA

Relating responsible sourcing to LCA is interesting. Perhaps, certified materials will exhibit different sustainability profiles compared to noncertified materials. Life cycle inventory data, especially those in databases, typically represent an average production profile describing a process or product. Sometimes, the reliability and quality of data are known but often their representativeness is not clear. Certification of a commodity (or of a producer) segregates a selected group from the whole population. This effectively creates and defines a new commodity category, which is physically identical but has known provenance as defined by certification criteria. Certified material will have a different average LCA profile than noncertified material—to the extent that the certification attributes can be discerned in the data. For conflict-free metal, LCA would likely not discern environmental differences; however, performance variation should be visible if indicators related to social sustainability or geopolitical risk. If environmental or energy criteria are used in certification, certified material would exhibit an improved LCA profile. For example, as proposed for the aluminum program (Aluminium Stewardship Initiative 2014), compliant smelters must meet energy and greenhouse gas emission performance, which would result in improvement of greater than 10 % compared to average commodity metal.

Responsible sourcing offers other opportunities regarding the origins and sources of raw materials, for example by providing geographic resolution at the country level or on producer companies. This is of use to LCA for both inventory data and impact assessment methods, especially for social issues. Data quality associated with responsibly sourced materials will likely be of high quality, given scrutiny by third-party auditors, thus potentially supporting better performance analyses and LCM decisions. Lastly, current LCA impact indicators used for the Area of Protection “natural resources” are weak (Schneider et al. 2011). Data and methodologies from responsible sourcing programs may help improve upon existing methods or point to new indicator frameworks for assessing resource extraction, social impacts, or resource supply risk (Gemechu et al. 2015). “Conflict” is a social aspect that is not yet included in product life cycle sustainability assessment. This is a rich avenue to explore.

10 Limitations and future research

Quality control in the study was performed via member validation which is done to improve research accuracy, validity and reliability (Bryman et al. 2011). This included submission of written summary reports to informants, presentations at workshops, and discussions regarding interpretations and research findings. Feedback was incorporated into the analysis, helping the research characterize responsible sourcing and examine the strengths, weaknesses, and opportunities of certification as a tool. The research is intentionally limited by the research framework—which was modified as the study progressed. Information on the conflict mineral programs is public and can be replicated, other than the empirical confidential data obtained on the CFSP. Reliability is supported by cross-checking among the 16 programs to confirm areas of overlap and commonality, although some findings relied significantly on the details of a single case and there is a risk on overreliance on a limited set of informants. The study proposes generalizations on raw materials and responsible sourcing. Although the results pertain to a subset of specialized metals, external validity is supported by reference to established product chain approaches, and findings contribute to the scholarship of SSCM and notions of LCM practice.

Future research is suggested in applied and theoretical aspects of responsible sourcing. First, there is a need to examine performance outcomes of conflict-free programs on social and environmental conditions in the Great Lake Region of Africa. Empirical work should be done to quantify amounts of 3TG metal production and stocks, possibly using material flow analysis, and could compare noncertified to certified amounts. For LCA and LCM, it will be interesting to see if and how responsible sourcing practices are reflected in sustainability assessments of end-products. The identification and characterization of product chain chokepoints need elaboration for other raw materials and commodities, with consideration of potential for responsible sourcing. For sustainability standards and certifications, there is opportunity to compare responsibility management systems to more conventional product performance standards, to study areas of stakeholder legitimacy and program authority, and to consider auditing practices and accreditation of auditors associated with programs. For SSCM, the conflict-free sourcing arena offers rich data on a mix of buyers and sellers, on facilities in developing countries, and on suppliers who are multiple tiers distant from end-buyers. Of interest are management and motivations of raw material suppliers, to understand how market forces like pricing and end-buyer engagement strategies influence supplier compliance.

11 Conclusions

The electronics industry and other manufacturers, motivated by corporate responsibility and regulation, are collaborating in programs that rely on market forces, standards, and auditing to address the conflict mineral problem. Responsible sourcing is implemented by collaboratively focusing on a limited group of several hundred companies that form a chokepoint in the global 3TG metal supply chain. Responsibility management systems have been voluntarily implemented at smelters and refineries, reaching a high level of compliance in a relatively short 4-year duration. Although social outcomes are difficult to correlate to responsible sourcing, metal market expectations have shifted in some product chains in response to conflict-free sourcing.

Responsible sourcing can be described, alternatively, as LCM given its full-life cycle scope or as SSCM given the emphasis on compliance and management systems. Understanding of both sustainability management approaches is expanded based on research findings. Downstream manufacturing focal companies support multi-sector compliance programs and engage in supplier development strategies. Responsible sourcing of 3TG metals addresses social issues across multiple tiers in product chains, reaching raw material suppliers in more than 25 countries. Smelters and refinery firms implement responsibility management systems and act as focal companies to their raw material suppliers. Some programs operate closed pipelines that deliver conflict-free metal around the world.

Acknowledgments The author acknowledges the cooperation and support of the Electronic Industry Citizenship Coalition, Global e-Sustainability Initiative, and the Conflict-Free Sourcing Initiative and is grateful for comments from Liz Muller and three anonymous reviewers.

Conflict of interest The author is a member of the Audit Review Committee of the Conflict-Free Smelter Program.

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